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TECHNICAL REPORT NO. 3-726

MOBILITY ENVIRONMENTAL RESEARCH STUDY
A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY

Volume V

HYDROLOGIC GEOMETRY

by

[illegible]. E. Garrett
J. H. Shamburger

November 1967

Sponsored by

Advanced Research Projects Agency
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U. S. Army Materiel Command

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U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
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FOREWORD

The study reported herein was performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the Office, Secretary of Defense (OSD), Advanced Research Projects Agency (ARPA). This report describes portions of two tasks of the overall Mobility Environmental Research Study (MERS) sponsored by OSD/ARPA for which the WES was the prime contractor and the U. S. Army Materiel Command (AMC) was the service agent. The broad mission of Project MERS was to determine the effects of the various features of the physical environment on the performance of cross-country, ground-contact vehicles and to provide therefrom data that can be used to improve both the design and employment of such vehicles. A condition of the project is that the data be interpretable in terms of vehicle requirements for Southeast Asia. The funds employed for this study were allocated to WES through AMC under ARPA Order No. 400. The study was performed during the period June 1964-November 1965 under the general guidance and supervision of the MERS Branch of the WES, the staff element of WES responsible for the technical management and direction of the MERS program.

This volume is one of an eight-volume report entitled A Quantitative Method for Describing Terrain for Ground Mobility. These volumes are:

I: Summary
II: Surface Composition
III: Surface Geometry
IV: Vegetation
V: Hydrologic Geometry
VI: Selected Air-Photo Patterns of Terrain Features
VII: Development of Factor-Complex Maps for Ground Mobility
VIII: Terrain Factor-Family Maps of Selected Areas

Field data were collected in Thailand between July 1964 and May 1965 by a three-man team. Personnel who served on this team at various times were: Messrs. H. W. West and B. T. Helmuth, Area Evaluation Branch (AEB), Mobility and Environmental (M&E) Division, WES; Mr. V. H. Anderson and PVT G. Cunningham, U. S. Army Cold Regions Research and Engineering Laboratory (CRREL); and Messrs. Ruangvitya Chotibitayathamin, Sarid Srithirom, Sriwiroj Chantawong, Anuvat Laophanich, Thamnoon Mongkol, Boonkiat Sirimontaporn, Suchart Supaphol, Taweesak Suwanpitak, and Tawee Klinproung, MERS Field Detachment, Bangkok, Thailand. Field sampling was under the direct supervision of a data collection leader. This position was occupied for periods of 3 to 4 months each by Messrs. W. K. Dornbusch, Jr., and J. D. Broughton, WES Geology Branch, and Mr. Ruangvitya Chotibitayathamin, MERS Thailand Detachment. The data collection accomplished by CRREL was under the direct supervision of Mr. R. E. Frost, Chief, Photographic Interpretation Division, CRREL. Data reduction and map preparation were accomplished by a team composed of Messrs. E. E. Garrett, team captain, H. W. West, W. W. Allred, and M. A. Zappi of AEB. The report was written by Messrs. Garrett and J. H. Shamburger, WES Geology Branch. The data reduction and map preparation phase was conducted under the direction of Mr. Shamburger. Technical assistance in various phases of the work was provided by Mr. A. A. Rula, Chief, Mobility and Environmental Research Studies Branch. All phases of this study were under the direct supervision of Mr. W. E. Grabau, Chief, AEB, and Dr. C. R. Kolb, Chief, Geology Branch, and under the general supervision of Messrs. W. G. Shockley and S. J. Knight, Chief and Assistant Chief, respectively, of the M&E Division, and Messrs. W. J. Turnbull and A. A. Maxwell, Chief and Assistant Chief, respectively, of the Soils Division.

Directors of the WES during the conduct of this study and preparation of this report were COL Alex G. Sutton, Jr., CE, and COL John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
feet per second	0.3048	meters per second

SUMMARY

This volume presents the methods used in collecting hydrologic geometry data in selected areas in Thailand. The selection, analysis, and classification of parameters significant to vehicle mobility are discussed. The photo-interpretation methods used in identifying hydrologic geometry features from aerial photographs (air photos) and the extrapolation of these identifications to areas not investigated on the ground are presented. The rationale for cartographic portrayal of these parameters is explained. Utilizing the collected field data, available air photos, and the Army Map Service series of topographic maps, hydrologic geometry factor maps were prepared covering the six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Chanthaburi, Pran Buri, and Khon Kaen). The maps are presented in Volume VIII of this series.

It proved only partially possible to determine the existence and value of the chosen parameters from air photos since some of the individual factors are wholly or partially below the water surface. Nevertheless, photo interpretation plus extrapolation from measured sites made it possible to map the parametric values by class range with reasonable validity. Recommendations are made involving improvement in data-collection techniques.

MOBILITY ENVIRONMENTAL RESEARCH STUDY

A QUANTITATIVE METHOD FOR DESCRIBING

TERRAIN FOR GROUND MOBILITY

VOLUME V: HYDROLOGIC GEOMETRY

PART I: INTRODUCTION

Background

1. Hydrologic geometry as a factor family, per se, comprises factors that are partially or wholly related to other factor families. That is, it includes factors that are treated more specifically in the consideration of surface geometry and surface composition. For example, the shape of a stream channel is properly a surface geometry feature, and the soils in the bed and banks are surface materials. The justification for making hydrologic geometry an independent factor family lies in the fact that surface geometry features and surface materials, in association with water, produce an array of unique effects on numerous military activities.

2. This array of effects tends to focus sharply, but not exclusively, on the water margins. Amphibious vehicles operate relatively independently of water depth, but they are extremely sensitive to the angle at which they can enter or leave the water. Progressive changes in buoyancy and center of gravity take place as a vehicle passes from a state of flotation, through partial support, to complete ground traction. Amphibious vehicles are also sensitive to current velocity and wave action. Through the operation of such factors, the water-land interface assumes great significance for cross-country mobility. Consequently, the data collection systems described herein are designed to provide detailed information on the dynamic characteristics of water in motion as well as the interface between water, land, and air. In view of this, the data array consists of details of three sets of properties: the surface geometry or cross-sectional shape of the entire channel, including its banks; the composition and strength of the materials forming the channel;

and the water depth and current velocity.

3. As with surface geometry,[1] no completely satisfactory method of describing and classifying surface-water bodies in an objective and quantitative manner is presently known. Hydrologic geometry is faced with the same problem of describing an irregular three-dimensional surface as is surface geometry. Also, hydrologic geometry encompasses the requirement of describing very large variations in geometric conditions that occur within short distances and/or even within relatively short periods of time. For example, a single period of rain may change streams from sluggish trickles to rapidly moving floods several meters deep.

4. These dynamic and transient characteristics, coupled with the complexity of an irregularly warped surface, make it impossible to fit descriptive data into an established classification system. Therefore, the investigator is faced with the necessity of measuring and recording sufficient basic data so that, hopefully, the requirements of any classification system that may emerge in the future can be met.

Purpose and Scope

Purpose

5. The overall purpose of this study was to collect, analyze, and present data on surface composition, surface geometry, vegetation, and hydrologic geometry in selected areas presumably representative of Thailand, with two definite objectives in view. The immediate objective was to assemble these data in such a form that they could be used to determine the effects of terrain on the cross-country mobility of ground-contact vehicles in environments characteristic of Southeast Asia. The long-term objective was to further the development of quantitative methods for describing those terrain factors that significantly affect vehicle mobility in terms suitable for their use as input to a mathematical or analytical vehicle-speed prediction model.

6. The specific purpose of this study was to measure the principal hydrologic geometry factors known or presumed to affect vehicle performance in selected areas of Thailand, to develop methods for estimating factor

values by the interpretation of aerial photographs (air photos), and to classify and map the significant factor values in the selected areas.

Scope

7. The results presented in this study were derived primarily from analyses of 554 sites within the six primary study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi) (fig. 1). The data were collected in the field in the period July 1964-May 1965. Interpretation of air photos constituted a major source of information for the factor maps, but scale and vintage of the air photos (see legend in fig. 1) affected the accuracy and reliability of interpretation.

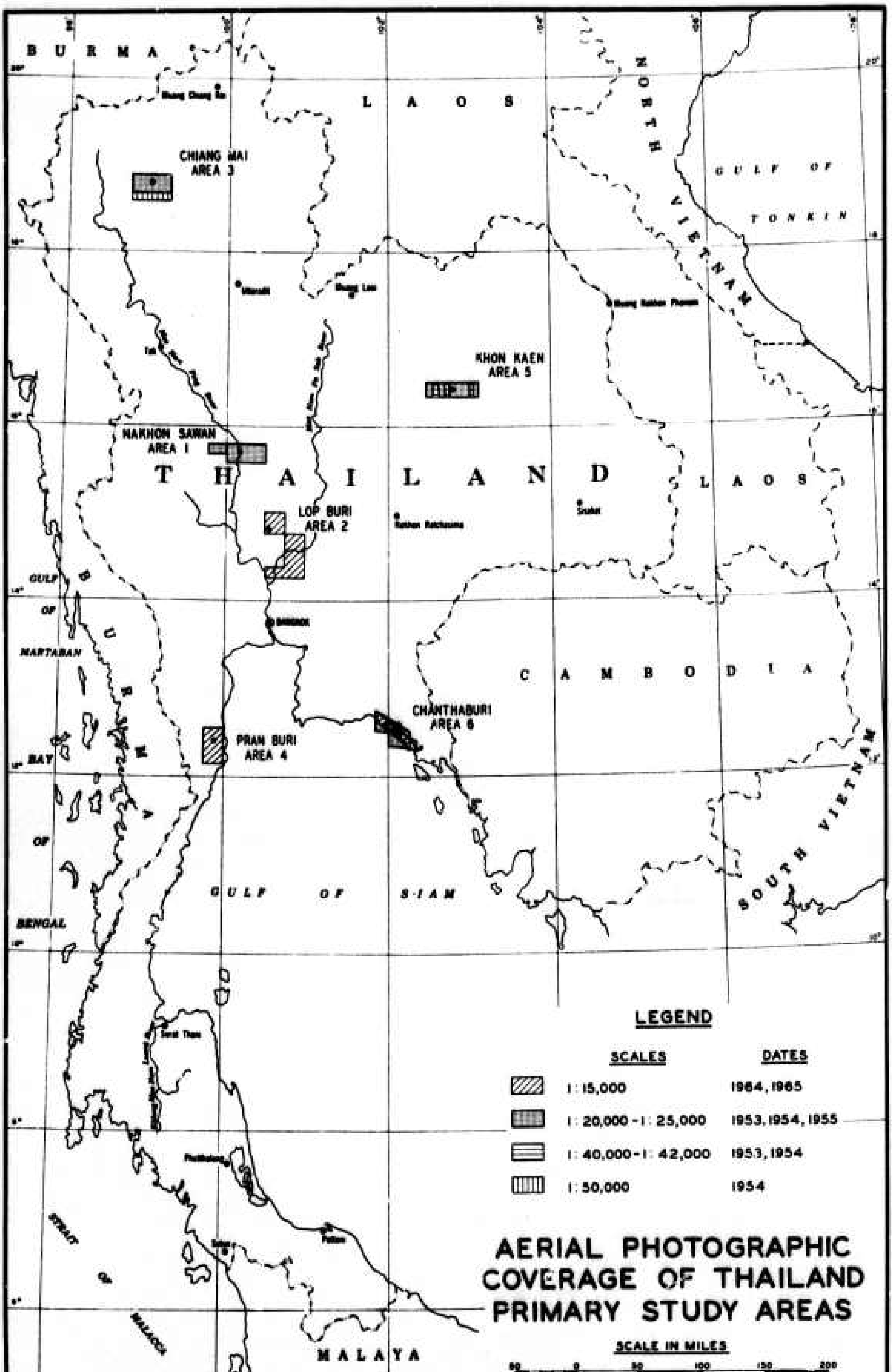


Fig. 1. Primary study areas in Thailand

PART II: DATA COLLECTION PROCEDURES

8. "Water body" is used as a general term to encompass such hydrologic features as canals, streams, lagoons, and even lakes and reservoirs. These hydrologic features within Thailand do, in fact, grade from one to another to such an extent that the categories are often indistinguishable.

9. For the purpose of collecting field data, a channel or basin with a water depth of 25 cm or greater for a total period of one week of the year was considered a hydrologic geometry feature. Conversely, a channel or basin with a lesser amount of water (or even a greater amount of water for a shorter period of time) was categorized as a surface geometry feature. However, before the data were analyzed and mapping was begun, these definitions were revised. The revisions are discussed in paragraph 18. It was evident that it would often be difficult or impossible to establish the proper category into which a specific feature should be placed. This was not regarded as serious because the precise categorization of a feature is of distinctly secondary importance. The important thing was to measure adequately all features. Therefore, borderline cases were placed in one category or another and thus recorded.

10. No attempt was made to actually measure the plan geometry of water bodies. Since most of the area studied is covered by adequate maps and/or air photos, it was felt that in most instances the areal arrangement could be more rapidly obtained from them than from time-consuming field measurements. However, sketches of the local channel configurations were always made.

Selection of Sites

11. Water channels vary so greatly within relatively short distances that no detailed instructions for the selection of sampling sites could be given. The general intent of the sampling program was to establish the nature and range of variation for the hydrologic geometry features in the areas studied. The following general considerations were given to the selection of sites:

a. Channels of all sizes and types (natural and artificial) should be sampled.

b. Channels of sinuous and meandering types, wherever possible, should be sampled both at a bend and an adjacent crossover (fig. 2).

c. Each channel should be examined for basic variations in cross-sectional configuration, and each variation should be measured, if possible.

d. Sites should be selected at bridges only as a last resort because the channel configurations at such sites are usually abnormal as a result of the presence of piers or control works. Where sites must be selected nearby, care must be taken to ensure that the locations are beyond the influence of the bridge.

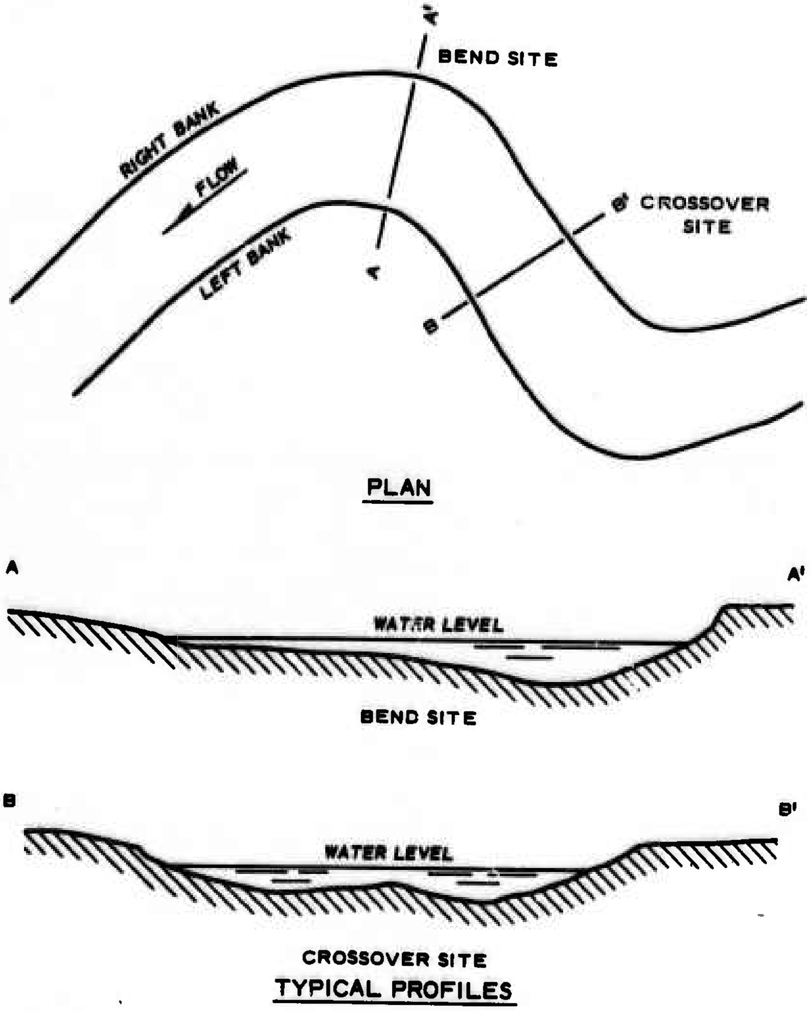


Fig. 2. Study site location on sinuous or meandering channels

Topographic Description and Measurement of Sites

12. The usefulness of an environmental description of a site depends upon a knowledge of its exact location, the physiographic context in which the site occurs, and the time at which features at the site were measured, since two identical configurations can occur as the result of different genetic processes. Often the only way to distinguish between the configurations is by identifying the geographic context and noting the time at which the description was made. Location is of absolute importance, because a mislocated point of ground truth can lead a photo interpreter badly astray; the sample point may be located on the photograph in a pattern different from that in which it actually occurs. Accordingly, for every sampled location data were recorded on a hydrologic geometry site description form. Fig. 3 is an example of this form with typical data inserted. Instructions for completing this form are given in the Environmental Data Collection Manual.[2]

13. Since a vehicle traversing any terrain reacts only to the surface with which it is in contact, it is necessary to determine the configuration of a 3-m-wide strip of terrain approximately corresponding to the vehicle width along the presumed course in order to reduce the vehicle/terrain relation to analytical terms. To determine the topographic configuration of this strip, an appropriate number of cross sections must be measured. The number of cross sections to be measured depends on the complexity of the surface. Ideally, there should be enough to enable reproduction of the surface from the data alone. Usually, two cross sections were measured at each site. However, artificial channels were often of such uniform cross section that a second cross section would have been superfluous. Occasionally, three cross sections were measured, but limitations of time usually dictated that not more than two be measured. The profiles were measured in a direction normal to the channel and were of sufficient length to encompass the maximum width of the channel under the highest expectable water conditions.

14. The procedures followed in measuring the cross sections are detailed in the previously cited Environmental Data Collection Manual

WES FORM NO. 1370
FEBRUARY 1964

SITE DESCRIPTION DATA FORM

(HYDROLOGIC GEOMETRY)

SITE NO.: 1-H-10 DATE: 21 Aug 64 COUNTRY: Thailand

MAP REFERENCE: Changwat Nakhon Sawan, Thailand, Sheet No. 5058 III

GEOGRAPHIC COORDINATES: Long. 100°04'52" East, Lat. 15°41'27" North

NAME OF WATER BODY: Map Name - Khlong Bang Pamung

SITE ELEVATION: 26 meters AZIMUTH OF PROFILE: 316° CURRENT DIRECTION: West

Grid Coordinates: 158348 SHEET 1 OF 1

POSITION OF SITE:

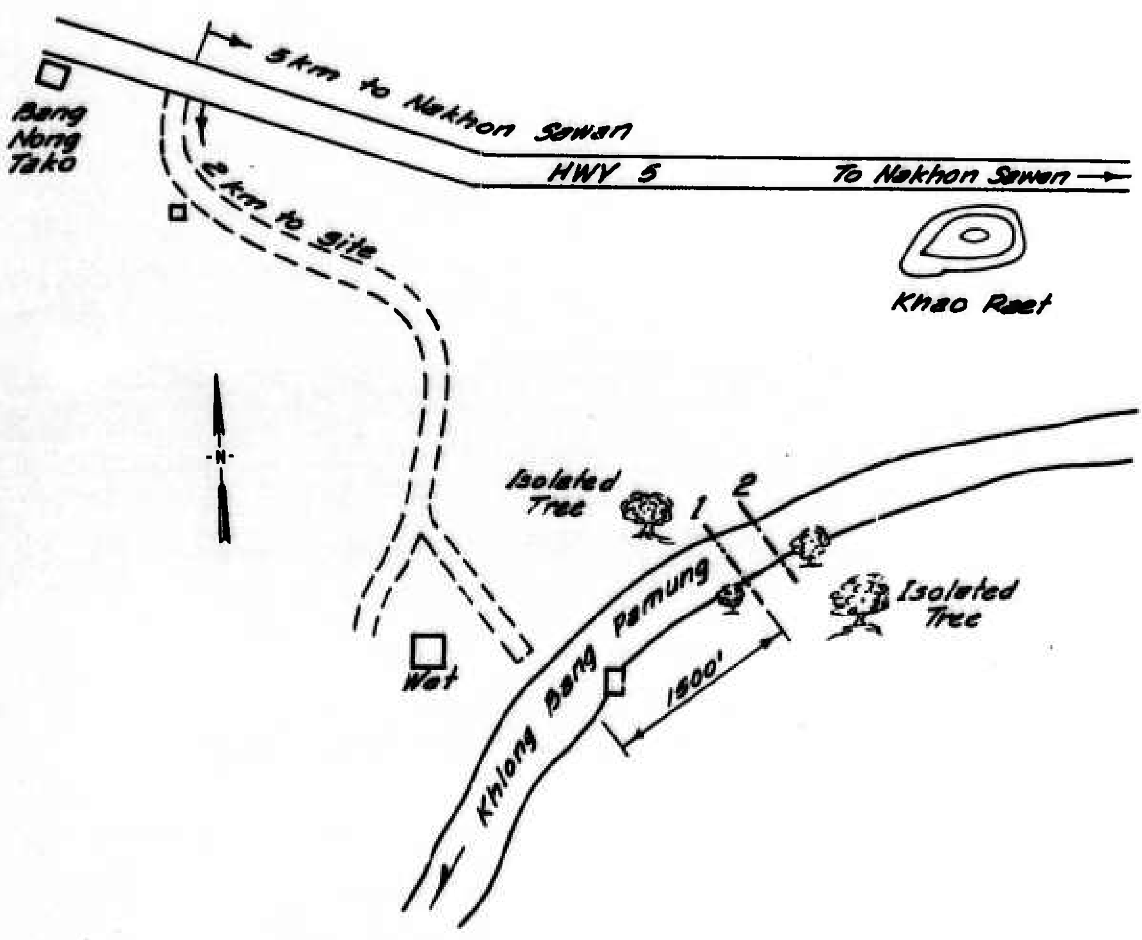


Fig. 3. Completed site description data form

(paragraph 12). The details of procedure varied from site to site in order that specific situations could be accommodated. Figs. 4 and 5 present examples of typically completed additional forms on which the data taken at all hydrologic geometry sites were recorded. Nearly all hydrologic geometry measurements in Thailand were recorded in British units, primarily because all of the readily available instruments were so calibrated. Since the field data were in British units, all subsequent data manipulations (see Appendix A) were also performed in British units.* In general, relative elevations were measured at every point along the cross section where there was an obvious change in slope. Cone index profiles were taken in every obviously different soil type or soil condition, and normally additional cone index profiles were taken at the edge of the water (fig. 4, second and third cone index records**) regardless of other considerations. Soil types were usually identified only by field observation, and then only the 0- to 6-in. layer was examined. Only rarely were samples taken for laboratory analysis. At the time of sampling, the water level was taken, and the maximum water level, as indicated by high-water marks, was noted. Where the depth was over 25 cm, it was usually obvious from looking at the water body that this depth persisted for greater than one week per year. Where water depths were less than 25 cm at the time of measurements, high-water marks, conversation with people living in the vicinity, etc., usually permitted establishment of the fact that the feature in question fit the definition of a hydrologic geometry feature. When practical, current velocities were measured at several points along the cross section, with the points chosen to give a reasonably reliable current velocity profile across the channel. Photographs were taken of all aspects of the site.

15. The body of data, as outlined above, constitutes the factual basis on which the subsequent analysis and interpretation were

* A table of factors for converting British units of measurement to metric units is presented on page vii.

** The values entered on this form are averages of multiple cone penetrometer values; the cone penetrometer data (cone index values) are recorded in the field on a "Trafficability Data Form," illustrated in fig. 5.

WES FORM NO. 1373
FEBRUARY 1964

HYDROLOGIC GEOMETRY DATA FORM

SITE NO.: 1-H-10 DATE: 21 Aug 1964 COUNTRY: Thailand

NAME OF WATER BODY: Khlong Bang Pamung

GENERAL LOCATION: From check Sta Hwy # 5, 5km NW - 2 km SE

MEASURED BY: West and Helmuth UNIT MEASURE: British

⊗ MAXIMUM WATER LEVEL SHEET 1 OF 2

■ WATER LEVEL AT TIME OF SAMPLE HI 3.70

PROFILE NUMBER	PROFILE OFFSET	DISTANCE FT	VERTICAL OFFSET, FT	CONE INDEX 0"	6"	12"	18"	SOIL TYPE 0-6" LAYER	CURRENT VELOCITY	REMARKS
1	0	-18.0	3.00							
		0.0	3.90	83	67	93	130	Clay		Bulk Sample 0-12'
		9.0	6.59							
	■	13.0	8.02	0	10	25	30	Clay		
		20.1	12.62						@1' 0.17 ft/sec	
		29.4	15.22						@1 0.18 "	
		39.4	15.88							
		48.3	16.36							
		60.1	16.42						@1' 0.37 ft/sec	
		69.3	16.32							
		81.0	16.27						@1' 0.24 "	
		91.8	13.94						@1' 0.14 "	
		112.0	11.02							
		105.6	9.57							
	■	109.8	8.02	0	37	33	27	Clay		
		113.6	6.68							
		124.5	4.62							
		134.5	4.21							
2	10'	0.0	4.21							
		-18.0	2.59							
		0.0	3.94							
		7.0	5.76							
	■	14.0	7.86							
		18.5	10.86							
		26.5	14.91						@1' 0.16 ft/sec	
		36.0	15.56							
		46.4	16.22							
		54.3	16.21						@1' 0.26 "	
		63.3	16.61							
		74.6	16.19						@1' 0.20 "	

Fig. 4. Completed hydrologic geometry data form (sheet 1 of 2)

WES FORM NO. 1373
FEBRUARY 1964

HYDROLOGIC GEOMETRY DATA FORM

SITE NO.: 1-H-10 DATE: 21 Aug 1964 COUNTRY: Thailand

NAME OF WATER BODY: Khlong Bang Pamung

GENERAL LOCATION: From Check Sta. Hwy #5, 5km NW-2km SE

MEASURED BY: West and Helmuth UNIT MEASURE: British

⊗ MAXIMUM WATER LEVEL SHEET 2 OF 2

⊠ WATER LEVEL AT TIME OF SAMPLE

PROFILE NUMBER	PROFILE OFFSET	DISTANCE FT	VERTICAL OFFSET, FT	CONE INDEX 0"	6"	12"	18"	SOIL TYPE 0-6" LAYER	CURRENT VELOCITY	REMARKS
2 (cont.)	10'	82.9	15.86							
		89.0	14.41							
		95.0	11.86							
		100.2	10.11							
	⊠	105.6	7.86							
		112.5	5.45							
		122.5	3.17							
		134.5	3.00							

⊗ 1' above Gd. Sta. 0.0 on Profile No. 2.

Fig. 4. (sheet 2 of 2)

TRAFFICABILITY DATA FORM
(HYDROLOGIC GEOMETRY)

SITE NO. 1-H-10 DATE 5 Dec 64 COUNTRY Thailand

NAME OF WATER BODY Khlong Bang Pamung

MEASURED BY West and Suchart SHEET 1 OF 1

DISTANCE FT		CONE INDEXES AT INDICATED DEPTHS							NOTES
		SURFACE	7.5 CM (3 IN.)	15.0 CM (6 IN.)	22.5 CM (9 IN.)	30.0 CM (12 IN.)	37.5 CM (15 IN.)	45.0 CM (18 IN.)	
0.0		80	80	70	70	90	120	190	Bulk sample
		110	140	80	70	120	100	100	0"-12"
		60	40	50	70	70	80	100	clay
	SUM	250	260	200	210	280	300	390	
	AV	83	87	67	70	93	100	130	
13.0 Water level		0	10	10	15	25	30	50	clay
		0	5	5	20	25	20	20	
		0	10	15	20	25	25	20	
	SUM	0	25	30	55	75	75	90	
	AV	0	8	10	18	25	25	30	
109.8 Water level		0	40	40	40	50	40	40	clay
		0	30	30	40	40	30	20	
		0	10	40	20	10	20	20	
	SUM	0	80	110	100	100	90	80	
	AV	0	27	37	33	33	30	27	
	SUM								
	AV								
	SUM								
	AV								
	SUM								
	AV								
	SUM								
	AV								

Fig. 5. Completed trafficability data form

established. Although the collection procedures incorporated all of the factors described above, it was anticipated that some of them, notably the soil type and cone index of bank and bottom and the current velocities, would be very difficult to interpret from air photos, especially if those photos were small scale. Data were collected, despite the expected interpretation problems, in order to provide as complete a description of each hydrologic geometry "type" as possible, on the chance that the data would subsequently prove useful, either for the MERS project or some later investigation. All of the basic data are on file at the U. S. Army Engineer Waterways Experiment Station.

PART III: DATA REDUCTION AND ANALYSIS

16. The sources of information that were consulted for the program of data reduction and analysis were: (a) the field measurements taken during the preliminary survey in 1962;[3] (b) Army Map Service (AMS) Series L708 topographic maps (scale 1:50,000); and (c) the information assembled under the MERS data collection program from July 1964 to May 1965. The availability of published data was determined through a literature survey[4] conducted as a separate MERS task. This survey revealed a considerable number (274) of references to hydrologic geometry of Thailand. However, only about 5 percent of these were pertinent to the study areas. Where references pertained to the areas of interest, usable information concerning profiles, soil type, and bank conditions of streams and rivers was consistently absent. Only a very limited number of the preliminary survey sites were positioned where the data could be applied. Therefore, the only practicable and useful data for this study came from the MERS data collection program and the AMS topographic maps.

17. During the period of data collection, 554 hydrologic geometry sites were sampled within the study areas shown in fig. 1. These sites were distributed among the study areas as follows: (a) Nakhon Sawan--46, (b) Lop Buri--125, (c) Chiang Mai--133, (d) Pran Buri--81, (e) Khon Kaen--105, and (f) Chanthaburi--64. Locations of these sites are shown on maps in Appendix A. These sites were selected from preliminary examination of air photos followed by ground reconnaissance. They encompassed as wide a variety of water body characteristics as time and accessibility allowed. Accessibility of sites was a limiting factor in Thailand because of the restricted road network. Sampling points were located where they could be reached by a 4-wheel-drive vehicle or by boat without undue loss of time.

Data Reduction

18. At the inception of the study and when the field data were being collected, the term hydrologic geometry was defined as inclusive

of any feature occupied by water to at least a 25-cm depth for a minimum of one week per year. On this basis, data appropriate to the factor family were recorded. However, after the conclusion of the data collection program, and when the analysis of the resultant information was contemplated, it became apparent that the original definition was not realistic in that it did not adequately accommodate the vehicle reaction to topographic configurations containing shallow water. In actuality, a vehicle crossing a water body of insufficient depth to alter significantly its ground-contact pressure or to affect its engine operation does not respond to the presence of the water. Consideration of this brought the obvious conclusion that such features should be considered as pertaining to surface geometry rather than hydrologic geometry. A decision had to be reached arbitrarily on the minimum depth of a water body that would significantly affect vehicle movement. To reach such a decision, specific vehicles had to be considered. Two were chosen: the M37 as representative of nonamphibious military vehicles, and the M113 as representative of vehicles with a "swimming" capability. The former has a maximum fording depth of 1.1 m. The latter becomes free-floating at a depth of 1.37 m. On this basis, and allowing an adequate safety margin, the minimum water depth chosen to distinguish a hydrologic geometry feature was fixed at 91 cm.

19. In addition, the obvious fact that many water bodies change depth and configuration very markedly on a seasonal cycle or even, in some cases, on a diurnal cycle (e.g. tidal channels) made it nearly mandatory that the maps contain information on both high- and low-water states. Obviously, in view of this, the time criteria described above (25-cm or more depth for a minimum of one week per year) had to be abandoned. Instead, a far less rigorous (and unfortunately partly qualitative) criterion was adopted: any feature containing water is a hydrologic geometry feature if it characteristically contains more than 91 cm of water during the appropriate "season." That is, a feature would be a hydrologic geometry feature during the dry season only if it characteristically contained more than 91 cm of water during that season, and

similarly for the wet season. In this context, "season" may imply either a yearly or a diurnal (i.e. tidal) cycle.

20. It was apparent that the division of water-containing features into wet-season and dry-season types would result in many features that would be hydrologic geometry features in the wet season and surface geometry features in the dry season. Such was, of course, found to be the case. Further, the redefinition of hydrologic geometry features by limiting consideration only to those containing 91 cm of water or more led to the conversion of many of the features that had previously been accepted as hydrologic geometry features (regardless of season) into surface geometry features, since the hydrologic geometry data collection teams selected sites on the basis of a minimum depth of 25 cm. Thus, a substantial body of data became available which, by all logic, should have been incorporated in the surface geometry data base. The difficulty lay in the fact that surface geometry (see Volume III of this series of reports) features were to be mapped on an <u>areal</u> basis, whereas all of the transformed hydrologic geometry data could be reasonably considered only on a <u>linear</u> basis, since without exception such data consisted of descriptions of shallow streams, canals, borrow pits, lake margins, and the like. In view of this, it was decided arbitrarily to include all linear surface geometry features on the same map used to present hydrologic geometry information. Since somewhat different parameter arrays had been developed for describing the two factor families (surface geometry and hydrologic geometry), these distinctions were maintained; therefore, the hydrologic geometry map requires a legend that encompasses both hydrologic and surface geometry (for example, see plate 1.1d of Volume VIII).[5]

21. There is no intent to map the width of channels or to indicate width by symbols. Standard conventions for the use of single or double lines for channels, as given in the AMS maps, indicate relative widths. These are not to be accepted as precise scalar representations. Lakes or other water-filled basins are shown as in the AMS base maps. The boundaries represent water-land contacts, not the 91-cm depth line, and are not based on conditions at a specified time in relation to seasonal water-land fluctuations.

22. In order to prepare a map of optimum utility, it was necessary to choose those parameters that are of greatest significance to vehicle mobility and that could be extracted from the available information. The number of parameters had to be limited so they could be comprehensibly presented on a map. Since vehicle test data were not available at the time this analysis was made, advantage could not be taken of that information to guide the choice of parameters. Within this framework, the following parameters (illustrated in fig. 6) were chosen:

Hydrologic Geometry	Surface Geometry
Contact approach angle (1)	Exterior terrain approach angle (6)
Step (2) height (3)	Interior terrain approach angle (6)
Position of step base (4)	Step height (7)
Water depth (5)	

---

(1) Contact approach angle is defined under two conditions: (a) where the water is between 0.91 and 1.37 m deep, and (b) where the water depth is greater than 1.37 m. The contact approach angle under condition (a) is the angle between the bed and the bank of the water body; under condition (b) it is the angle formed by a line parallel to and 1.37 m below the water surface, and the bank of the water body.

(2) A step is a facet of the channel bank that (a) is steeper than that portion of the bank where the contact approach angle is measured, (b) exceeds 35 deg in slope, and (c) is at least 15 cm in vertical height.

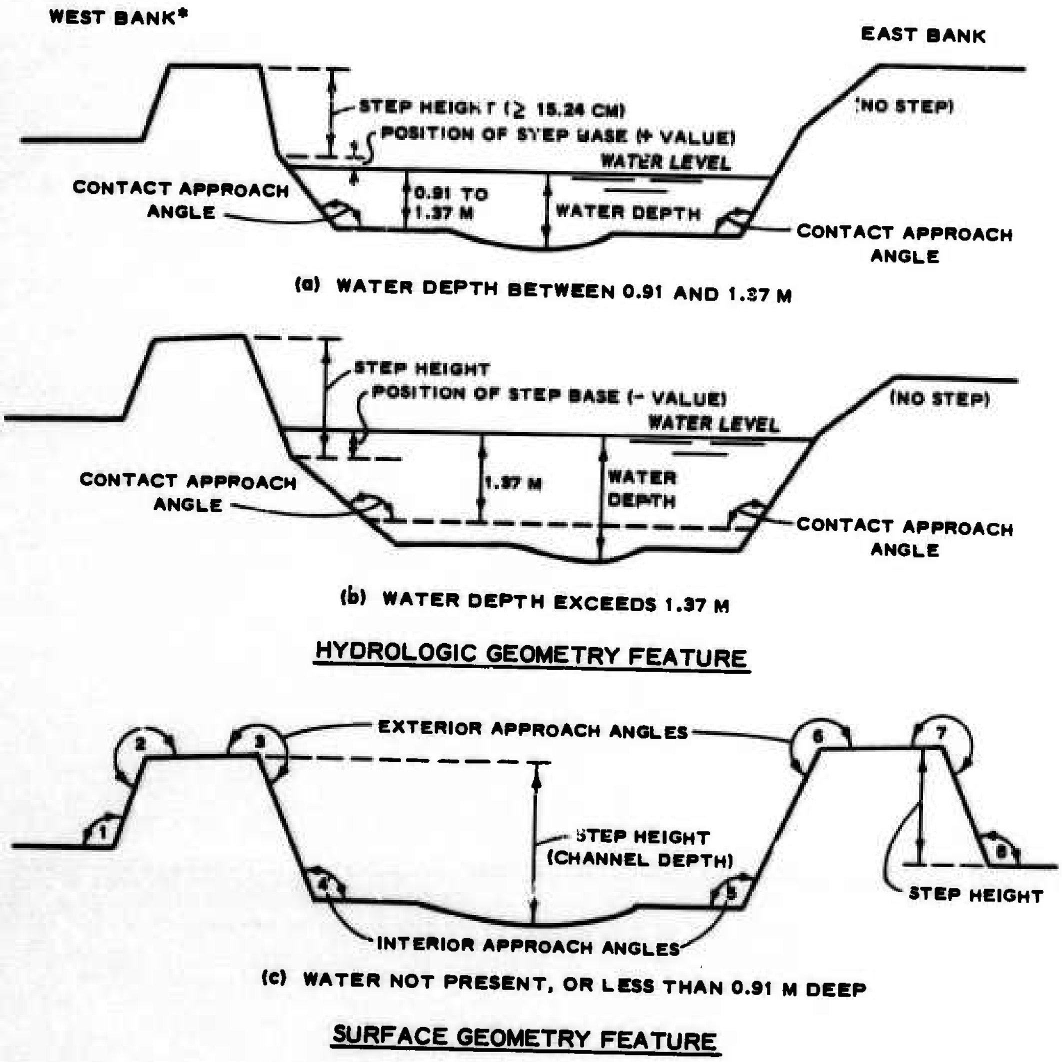
(3) Step height is the difference in elevation between the top and base of a step.

(4) Position of step base is defined as the vertical distance of the base of a step above or below the surface of the water.

(5) Water depth is the greatest vertical distance between the water surface and the bottom of a channel.

(6) An interior terrain approach angle is the angle formed between the bed and bank of a drainage channel. An exterior approach angle is the angle formed between the stream bank and the ground surface above the channel.

(7) Step height for surface geometry is the vertical distance from the lowest point in the channel to the top of the lower bank.



* NOTE: WEST BANK IS THE FIRST BANK ENCOUNTERED WHILE TRAVERSING AN AREA IN AN EASTERLY DIRECTION (I.E. AZIMUTH > 0 TO 180 DEG) AND THE EAST BANK IS THE FIRST BANK ENCOUNTERED WHILE TRAVERSING AN AREA IN A WESTERLY DIRECTION (I.E. AZIMUTH > 180 TO 360 DEG), ASSUMING THAT THE VEHICLE INTERSECTS THE FEATURE AT A RIGHT ANGLE.

Fig. 6. Nomenclature and location of components of features described under hydrologic geometry

Analysis of Data

23. The data analysis was accomplished by the following steps: (a) constructing cross sections from the field data, (b) measuring the appropriate factors to be mapped, and (c) recording those measurements on an appropriate form.

24. The cross sections were constructed (fig. 7) at an undistorted scale from the data on the Hydrologic Geometry Data Forms (figs. 4 and 5). All cross sections at a site were plotted on the same sheet and identified. Since the classification to be used as the basis for mapping was dependent upon water depth, every effort was made to define the various water stages. The first step in the process was to plot the water level at the time the sample was taken (fig. 7). If the maximum and minimum levels were noted on the data sheets (as in fig. 4) they were also plotted (fig. 7, cross section 2). An effort was then made to establish the mean maximum and mean minimum water levels. As used herein, the terms are deliberately chosen to exclude extreme water levels that may be reached only for a few hours, at intervals of several years, immediately following unusually heavy rains, or, conversely, only after abnormally protracted periods of drought. The estimation of mean maximum water level was based on such indications as the presence of "nicks" on the banks or the presence of floodplain features on the level of the surface in which the channel is incised. In some instances, the field teams noted evidences of high water, such as drift caught in trees, water marks on vegetation along the banks, reports by the local inhabitants, etc. The estimation of mean minimum water levels was much more difficult, and in many instances was hardly better than a guess. In a few fortunate cases, members of the field teams had seen the channel at a low water stage. In some instances the teams were able to obtain information from the local inhabitants. Lacking these sources of information, it was usually assumed that the mean minimum stage would just cover the flattest portion of the channel bottom.

25. Measuring and recording values along the cross sections were accomplished concurrently. Since the various angles on the actual profiles were often complex (e.g. a series of small facets together may compose any one of the angles as defined), the precise angle to be measured was often not apparent. The angle to which the vehicle responds depends on the geometry of the specific vehicle itself. In order to determine this precisely, scaled outline figures of the two vehicles previously chosen as representative of the types of military logistic carriers to be considered

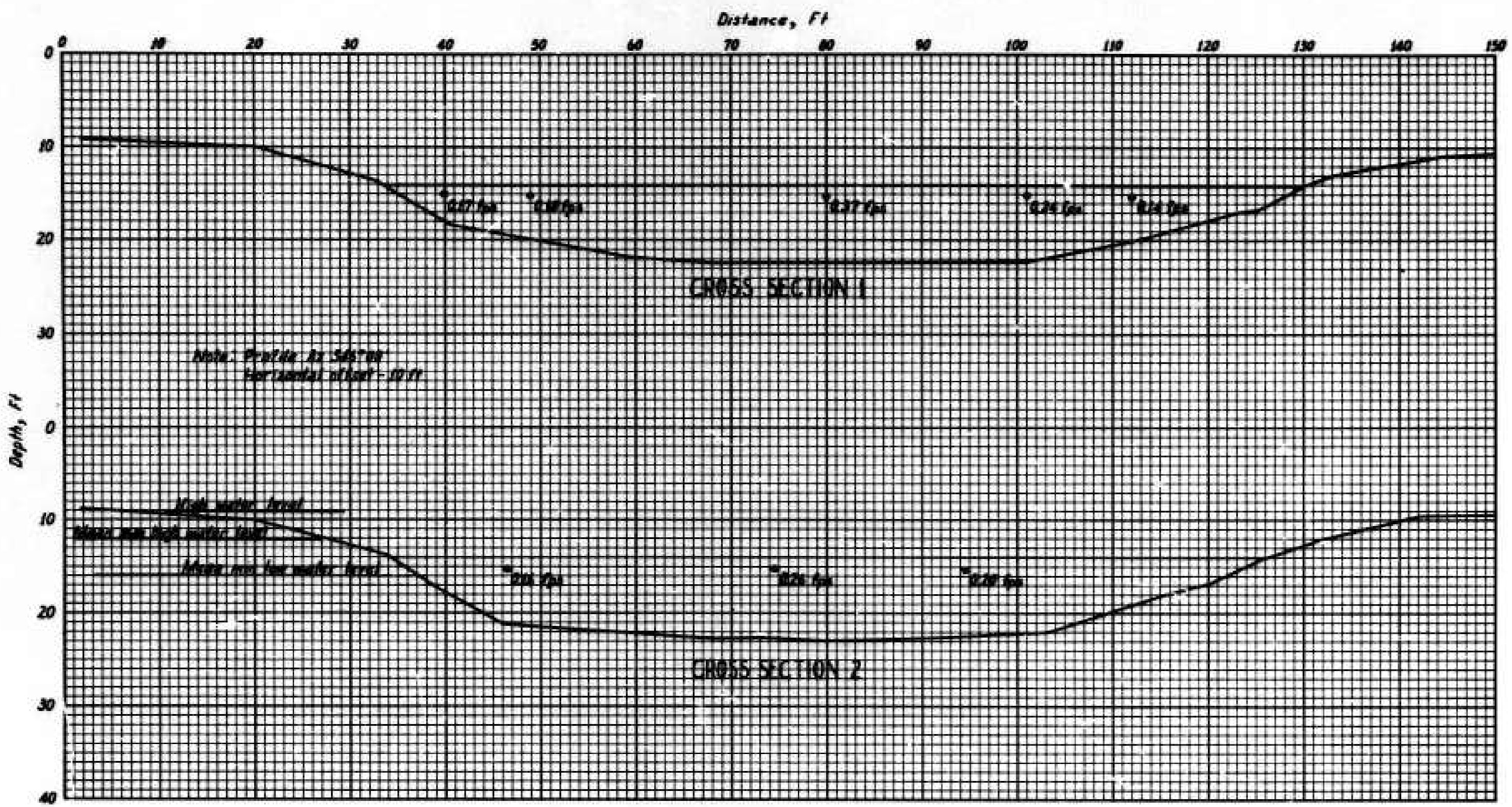


Fig. 7. Typical cross sections, Site 1-H-10, Nakhon Sawan study area

(the M37 and M113) were prepared on transparent acetate. These figures were then superimposed on the profiles (the M113 on hydrologic features and the M37 on surface geometry features), and the minimum angles encountered were measured with a protractor.

26. For the purpose of standardizing the location of all angular measurements, a numbering system was used to which the angles recorded for surface geometry features were referred. This is illustrated in fig. 6. It will be noted that angles 3, 4, 5, and 6, which are also termed the interior and exterior approach angles, are the only ones used for the factor maps.[5] Angles 1, 2, 7, and 8, not always present, are positioned on surface geometry features lying outside the channel area. They were measured and recorded with the corresponding step height (applicable to the surface features external to the channel--not to be confused with the step height corresponding to the channel depth).

27. A form (fig. 8) was devised to record the measurements and other pertinent data. In order to separate hydrologic geometry features from surface geometry features, the data form was designed so that both types were recorded on the same sheet. Thus, all terrain factor values describing a site are given on the same form. The forms were designed so that there would be a space for a notation (i.e. the recording of a factor value) for every possible factor. Since not all features exhibited every possible factor, many of the completed forms contain blanks (fig. 8). The data form does not incorporate either the current velocity data or the cone index data collected at each site. The current velocity measurements were omitted because it proved to be impractical to interpret that factor from the available air photos. Since the site data could not be extrapolated to unsampled areas, there was little point in including it on the data sheets. The cone index values collected at each site were also omitted on the data form, since these factors were not included as elements in the classification of either hydrologic geometry or surface geometry. These data were, however, used as a part of the ground truth for the mapping of surface composition.[6]

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	Contact Approach Angle, deg, Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Step** Height, in., Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Position of Step Base,† in., Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Water Depth ft, Max Wtr	Min Wtr
1-N-1	4958II	NS I	035465	175	160				24				-24			4	2
1-N-2	4958I	‡	985971	165	155	165	155	20	90	20	90	-18	-36	+24	0	6	3
1-N-3	4958I	‡	037607	175	170				60				+12			3.5	1
1-N-4	4958I	‡	996592	90	165			16				-26				3.5	1
1-N-5	4958II	NS I	957421	150	155				32				-36			5.5	1.5
1-N-6	5057I	NS IV	474239	175	170											5	2.5
1-N-7	5057I	NS IV	569258													2.5	1.5
1-N-8	5057I	NS IV	577278	155	175	155	175	72		72		-54		-12		7	3
1-N-9	5047IV	NS V	193310	165	170	165	165									9	5
1-N-10	5048III	NS II	159349	165	145	170	165		60		60		-60		0	8.5	4
1-N-11	5058III	NS II	115374	165	170	170	170	26	30	26	30	-48	-24	-12	+16	6	3
1-N-12	5058III	NS II	148437	135	100	135	100	102	120	102	120	-54	-48	0	0	24	19
1-N-13	5058III	NS II	166367	170	155				36				-36			5	2.5
1-N-14	5057IV	NS V	167257	165	155	125	140	162		48	18	-36		-48	+24	16	8.5
1-N-15	4958II	NS I	008441	140	160			24	18			-18	-12			3	1
1-N-16	4958II	NS I	997445	160	160	160	160		24		24		0		+12	5	3
1-N-17	4958II	NS I	841416	170	135			12	30			-12	-18			3	1.5
1-N-18	4958II	NS I	854419	140	160			18	24			-18	-12			3.5	0.5
1-N-19	4958II	NS I	881409													2	0.5
1-N-20	4958II	NS I	916427													2	0
1-N-21	5057IV	NS V	209322													2	0
1-N-22	5057IV	NS V	208144	175	175				18				-18			3.5	1.5
1-N-23	5057I	NS IV	444239													2.5	0
1-N-24	5057I	NS IV	344289													2	0.5
1-N-25	5057IV	NS V	316295													2.5	1

Site No.	Surface Geometry: Critical Approach Angle, deg and Step Height, in. 1†† App Angle	1†† Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
1-N-1					195	160	115	230			155	60	4.5
1-N-2													
1-N-3					185	165	140	220					7
1-N-4	140	26			220	90	165	200					5
1-N-5					190	150	90	270					6
1-N-6					210	150	155	190					6
1-N-7					190	160	160	185					3
1-N-8													
1-N-9													
1-N-10													
1-N-11													
1-N-12													
1-N-13					210	165	140	220					6
1-N-14													
1-N-15					215	150	145	220					4
1-N-16													
1-N-17					210	150	120	240					4
1-N-18	145	20			230	145	90	260					4
1-N-19					190	170	145	220					3
1-N-20	150	24			210	150	155	200					3
1-N-21	160	74			200	150	170	195					2.5
1-N-22					215	145	175	185					4
1-N-23	190	30			220	140	170	190					[illegible]
1-N-24	160	56			200	160	175	185					2
1-N-25	170	48			210	160	140	220					3

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
** A step is a slope change that is >35 deg.
† Position of step base is referenced to water level.
†† For position of numerically designated approach angle and step height see fig. 6.
‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Fig. 8. Hydrologic and surface geometry field data from Nakhon Sawan study area

Development of Class Ranges for Mapping

28. The data were analyzed to establish class ranges for mapping that would be meaningful in terms of vehicle response and recognizable or interpretable from air photos. It was desirable to correlate the class ranges with any naturalistic breaks if any could be detected. The criterion of potential recognition from air photos was required since the relatively low density of measured sites made it necessary to extrapolate the information to unsampled areas. Class ranges that could not be interpreted from air photos would render the mapping process almost totally impracticable.

29. Since the measured water depths did not reveal any preferred frequencies, class ranges of this factor were established on the basis of fording and floating depths of selected military vehicles (see paragraph 18).

30. Frequencies of occurrence of the other parameters were examined but failed to yield any pronounced modal concentrations. Consequently, the class ranges were selected more or less arbitrarily; however, items that would prohibit movement, such as maximum gradeability of the vehicles and the height of slopes exceeding 35 deg, influenced these "arbitrary" selections. The surface geometry data were analyzed in conjunction with the study of the surface geometry factor family, and the same classes were used. The rationale for selecting the surface geometry class ranges is discussed in Volume III of this series of reports. The mapping classes for the hydrologic geometry and surface geometry factors are shown in fig. 9.

31. After establishing the mapping classes, the data were placed on manually manipulated key-sort punch cards to facilitate rapid retrieval and comparison during map preparation. An example of a key-sort card with site data placed upon it is given in fig. 10. These cards contain both punched and written information. Punched information (fig. 10) consists of military grid coordinates of the site, code number of the study area, type of data (including both surface geometry and hydrologic geometry; the latter is categorized as "Water-Land Interface" on the cards),

HYDROLOGIC GEOMETRY FEATURES

CONTACT APPROACH ANGLE

Unit	Range
	deg
1	< 145
2	145-155
3	> 155-165
4	> 165-180

STEP HEIGHT

Unit	Range	
	in.	cm
1	< 12	< 30.48
2	12-< 24	30.48-< 60.96
3	24-< 36	60.96-< 91.44
4	36-48	91.44-121.92
5	> 48	> 121.92
x	step absent	step absent

POSITION OF STEP BASE

Unit	Range			
	in.		cm	
1	> 48	bwl[1]	> 121.92	bwl
2	> 36-48	bwl[1]	> 91.44-121.92	bwl
3	> 18-36	bwl[1]	> 45.72-91.44	bwl
4	1-18	bwl[1]	2.54-45.72	bwl
5	at water level			
6	1-12	awl[2]	2.54-30.48	awl
7	> 12-30	awl[2]	> 30.48-76.22	awl
8	> 30-48	awl[2]	> 76.22-121.92	awl
9	> 48	awl[2]	> 121.92	awl
x	step absent		step absent	

[1]Below water level.

[2]Above water level.

WATER DEPTH

Unit	Range	
	ft	m
1	3-4.5	0.91-1.37
2	> 4.5	> 1.37

LINEAR SURFACE GEOMETRY FEATURES

TERRAIN APPROACH ANGLE

Unit	Range
	deg
1	< 100
2	100-< 125
3	125-< 150
4	150-< 165
5	165-< 180
6	180-< 200
7	200-< 210
8	210-< 220
9	≥ 220

STEP HEIGHT

Unit	Range	
	in.	cm
1	0-4	0-10.16
2	> 4-10	> 10.16-25.40
3	> 10-18	> 25.40-45.72
4	> 18-30	> 45.72-76.20
5	> 30-48	> 76.20-121.92
6	> 48-66	> 121.92-167.64
7	> 66-84	> 167.64-213.36
8	> 84	> 213.36

Fig. 9. Mapping class ranges of hydrologic geometry and linear surface geometry features

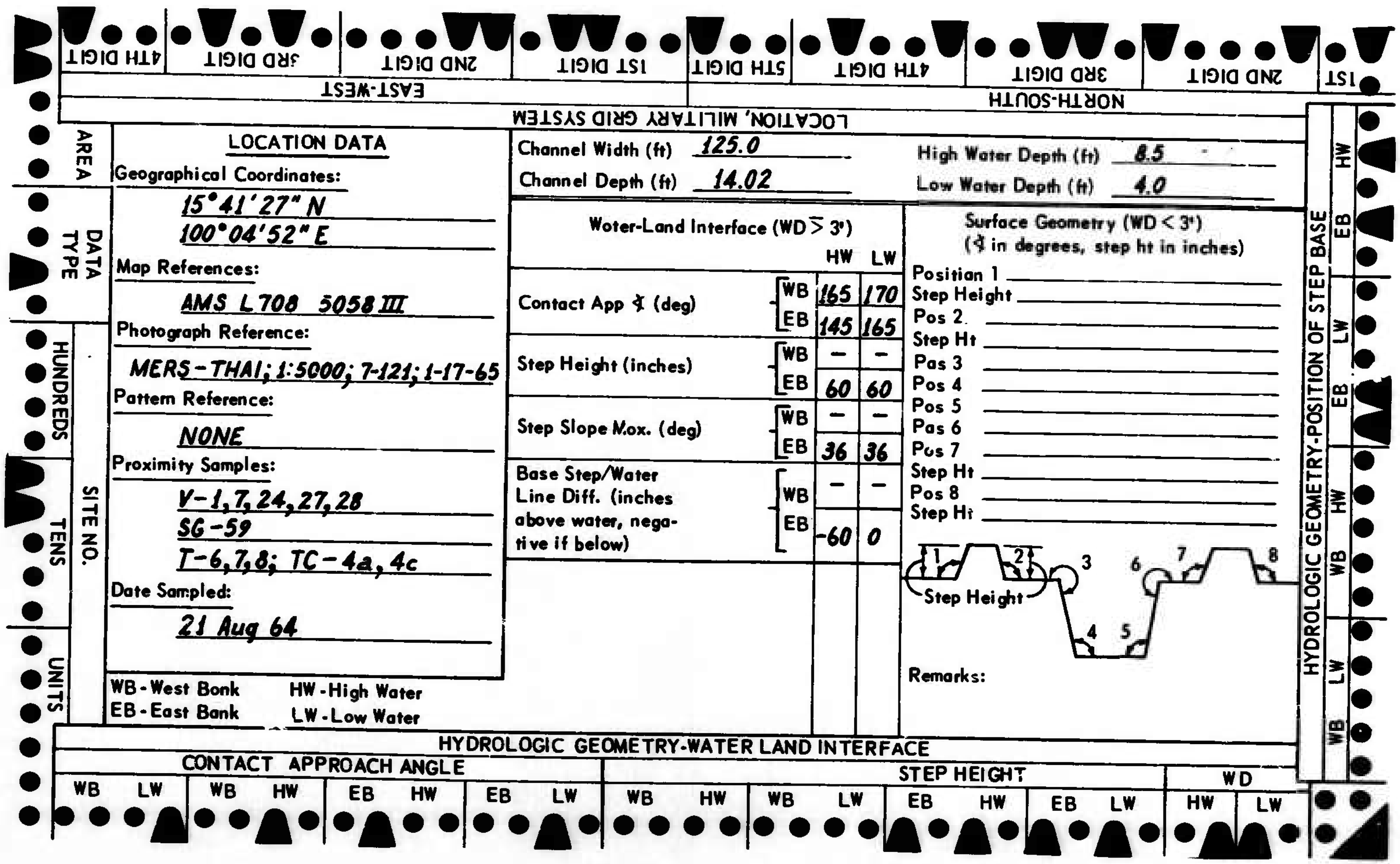


Fig. 10. Key-sort punch card for hydrologic geometry field data

site number, and classes for each factor--contact approach angle, step height, position of step base, and water depth for hydrologic geometry, and approach angle and step height for surface geometry features. The classes that describe each factor for both high- and low-water conditions for the hydrologic geometry factors were punched for each site. Written information consists of geographic coordinates, air-photo and pattern reference (see Volume III, this report), all samples taken in the vicinity for other factor families (entitled "Proximity Samples" on the card; see left side of fig. 10), sampling date, and information on the "Summary of Hydrologic Field Data" sheet.

PART IV: INTERPRETATION AND MAPPING TECHNIQUES

32. The data collected by the field teams describe only the exact places at which the data were taken. In order to map the distributions of factors and factor values for every point in the six primary study areas, a method had to be developed for extrapolating the point data represented by the samples to the entire area. Since the only sources of information on the areas of consideration were maps and air photos, this meant that for all practical purposes the problem was reduced to one of the development of map and air-photo interpretation techniques, principally the latter. A subsidiary effort involved the development of appropriate symbol systems for placing the interpreted information on the factor maps. Since all features of concern for the hydrologic geometry maps were linear, a system substantially different from that used for the other factor families (surface composition, surface geometry, and vegetation) was required.

33. The available air photos for this project varied in scale and quality. The scales varied from 1:50,000 to 1:15,000 (see fig. 1). The smaller-scale photographs, which were the only ones available for four of the six study areas, were taken approximately 12 years prior to this study. They are the photographs from which the AMS base maps were constructed. Consequently, all changes in drainage features developed within the past 12 years are not reflected on the maps. Air photos obtained in 1965 under a MERS contract were available for two areas (Lop Buri and Pran Buri) during the hydrologic factor mapping phase.

Air-Photo Interpretation Techniques

34. Two approaches can be followed for ascertaining the characteristics of features in an air photo. These are (a) direct measurement and (b) inference or interpretation based on the pattern the features exhibit in the photograph. Naturally, where ground measurements were available, these data were known characteristics and were used to identify the feature as well as to assist in extrapolating to similar patterns

in unsampled areas. The scale of the air photos coupled with the characteristics of the hydrologic features to be identified made direct measurements from air photos impossible. Therefore, a procedure had to be established whereby the characteristics could be inferred or interpreted.

35. The patterns exhibited by water bodies on air photos were identified on the basis of their tone, texture, and geometry. These characteristics are discussed in the following paragraphs. The method used to identify the physical characteristics of the water bodies will be discussed later in this report.

Pattern geometry

36. The origin of a water body, whether man-made or natural, is indicated by the geometric configuration of its air-photo pattern. For example, the uniformity with respect to width and straightness of a man-made canal contrasts greatly with a meandering river. Therefore, the discussion of pattern geometry of water bodies will be with respect to the origin of the feature.

37. Man-made water bodies within the study areas reported herein include canals, irrigation ditches, borrow pits, man-altered streams, etc. Photographs 1 and 2 are ground views of an irrigation canal and a borrow pit, respectively. Photograph 3 shows stream patterns that have been altered for irrigation purposes. Though canals vary in width, a specific canal can usually be identified by a pair of parallel lines a uniform distance apart. Several canals usually are associated to form a network of interconnecting parallel lines on an air photo. Included in this network are ditches that take off from the canals to the cultivated fields. Along the larger canals the parallel lines are broken by bridges, locks, and dams. Borrow pits are suggested by narrow elongate bands intermittently spaced along either or both sides of a railroad or road.

38. Natural water bodies vary more in shape than man-made features. The shapes and patterns of natural water bodies are influenced by several factors, including type of drainage (underground or surface), topography, volume of water and amount of sediment, type of material (soil type or rock), and tide. The resulting shapes vary from slightly curved to sinuous parallel or subparallel lines of various widths to irregular or circular or elliptical outlines.

39. Natural water bodies within the Thailand study areas are of the following types: (a) coastal features, (b) streams and rivers, (c) lakes, and (d) sinks.

40. Natural coastal features in the Chanthaburi and Pran Buri study areas include lagoons, estuaries, and tidal rivers. The shapes of these features vary from irregular for the lagoons and estuaries to sinuous subparallel lines that decrease in width inland for the tidal rivers. Tributaries joining the streams form irregular branching lines.

41. Streams and rivers vary in width and planimetric shape. Streams in areas of high relief (mountains and hills) are generally straighter and narrower than meandering streams with wide floodplains. In heavily vegetated areas some of these streams are obscured and are difficult to delineate. Stereoscopic examination is very useful in these areas. Meandering streams and rivers with wide floodplains exhibit circuitous parallel lines of various widths. Some of these water bodies are joined by numerous tributaries and abandoned courses, and their networks present distinctive identifiable patterns of crooked to looping connecting sets of parallel or subparallel lines. Arcuate swales (depressions) are common within the bends of these streams. Photograph 4 shows a natural lake in the vicinity of a bend at which a sample site was located in the Nakhon Sawan study area, and photograph 5 is a ground view of a medium-sized stream in the Khon Kaen study area.

42. The geometric outlines of lakes vary from two parallel or subparallel lines with arcuate shape to irregular bodies covering many square kilometers. Most of these water bodies are recognizable in air photos from their tone and texture. Photograph 6 shows a portion of a river segment and a natural lake. Note that the aquatic vegetation shown in the ground view of the sample site location (photograph 7) is also apparent in the air photo (photograph 6).

43. Sinks, typical of karst regions, are elliptical or circular depressions forming randomly oriented or subparallel patches that extend over a considerable area. These sinks may or may not contain water, depending upon their underground drainage characteristics.

Pattern tone and texture

44. Identification of water bodies (both hydrologic and surface geometry by definition) was aided considerably by the presence of water. Water usually produces a distinctive image on air photos; it can normally be identified by an amorphous texture and a light gray tone. This statement should not be construed to mean that every tone-texture of this type represents water, because in many cases other associations (such as topography) must be made. An amorphous texture simply means that there are no visible grains that form the tone. The tone of water bodies on a photograph can be altered by the presence of organic matter or vegetation, suspended soil particles in the water, and the reflection of sunlight on the surface.[7] Vegetation and soil particles usually darken the tone, and the reflection of solar rays tends to lighten the tone almost to white. In contrast to light-toned water bodies, certain water bodies such as swamps exhibit a dark tone that can be attributed primarily to organic content and presence of vegetation. The texture of these patterns varies between smooth for the exposed water to grainy for the water with vegetation in or on it. These features are associated with a low, undrained topographic position in reference to the surrounding terrain.

45. Contrast between the light gray tone of water and the medium to dark gray tone of vegetation along banks or levees is also a key to identification.

Stereoscopic examination

46. Stereoscopic examination of the photographs, which emphasizes differences in elevation, assists in identification of water bodies. For example, the sides or banks of larger canals appear to be higher than the surrounding terrain. In contrast the water-retaining depressions (sinks, swamps, borrow pits, etc.) lie at lower elevations than the surrounding surface. The water in rivers and streams also normally appears lower than the banks.

General comments

47. The photo interpretation process, with its requirement for very detailed examination of large numbers of air photos, was the most time-consuming component of the entire mapping procedure. Furthermore,

it was also the component that required the highest levels of experience and judgment. Since the factual base was necessarily restricted to spot locations, the interpolation between them was guided primarily by the appearance of the channels or water bodies on the photographs. Had it been possible to derive the factor values directly from the photographs, little more would have been required to produce a map of high reliability. Unfortunately, these factors could only be inferred. To further complicate the photo interpretation, some of the factors mapped were always partially or entirely below the surface of the water. Even if they were above the surface, their magnitude at the scale of photography available was too small for mensuration. This was true, in most cases, even with the new 1:15,000-scale photographs. Nevertheless, the inferences that could be drawn from the tonal gradations and image associations in the photos were numerous and valuable. By combining the measured data with the photo images, reasonably valid analogies could be drawn, and these analogies were used to interpolate between control points.

Mapping Procedures

48. The mapping phase of this study entailed the interpretation of the hydrologic geometry parameters from available data and the portrayal of the results on maps in terms of class ranges. As previously mentioned, two distinctive conditions were portrayed--high- and low-water conditions. An ambiguous situation exists in regard to the cyclical succession of high and low water, which should be explained. For the greater part of the areas mapped this cycle is seasonal and annual. However, for small areas in the Pran Buri and Chanthaburi study areas the cycle is daily (tidal), in which one high and one low tide occur in each ± 24-hour period. Since the map legends specify only that they pertain to mean maximum and minimum water conditions without regard to time cycle, no distinction is made between the seasonally and the tidally controlled areas. Also, in regard to the alternation of high and low water, a possibly misleading portrayal of some of the irrigation canals exists. Many of these are indicated as being hydrologic geometry features on the high-water maps

and surface geometry features on the low-water maps. A distinct possibility exists that the times of high and low water are reversed from seasonal rainfall periods for those irrigation features in which water for agricultural purposes may be concentrated at times when water in the natural drainage system is reduced. However, since no definite information is available concerning this possibility, no such indications are shown on the maps. The possibility also exists that fluctuation of high and low water in the artificial channels is irregular and not correlated with the seasonal cycle, but is controlled by local agricultural demands.

49. Before detailing the mapping rationale, the sources of information on which it was based should be mentioned again: (a) field measurements,* (b) air photos, (c) AMS topographic maps, (d) ground photography, (e) personal observation of the areas, and (f) background knowledge of hydrologic principles. All these items were used by personnel preparing the maps.

50. The development of the hydrologic geometry factor maps and the hydrologic geometry factor-family map[5] involved seven very general steps, as follows.

a. Plotting of sample locations. All of the points sampled by the field teams were plotted carefully on the 1:50,000 AMS topographic maps (AMS Series L708). In most cases the sample points were clearly associated with a hydrologic geometry feature such as a stream, canal, or lake, but in some instances the points fell in positions not obviously related to any mapped feature.

b. Construction of base map. With the sample point locations as a guide, a base map of all hydrologic geometry and linear surface geometry features was constructed (see paragraph 51). Where the points fell on mapped features, the entire extent of that feature as presented on the topographic map was traced. In those instances where the point was not related to a mapped feature, the sample location was transferred to the best available air photo; the feature that the sample described was examined, and that feature was traced throughout its extent. Where recent large-scale (1:15,000) photographs were available, many hydrologic

* In most cases two profiles were prepared for each sample site. These frequently differed with respect to their angular and step parameters. In such cases, one profile was arbitrarily chosen as representative of the site.

geometry or linear surface geometry features not shown on the AMS maps were identified and delineated. Examination of the new (1965) large-scale photos also revealed that a number of modifications in the planimetric shape and even the locations of hydrologic geometry features had occurred since the AMS mapping photos had been taken (chiefly from 1953 to 1955). Where such changes were noted, the base map was corrected accordingly. Where only small-scale (1:40,000 and 1:50,000) photos were available, very few features not mapped on the AMS maps were discovered. The only significant exceptions consisted of a few cases in which the map compilers had generalized very complex and fine-grained drainage patterns (as seen on the photographs) into much simpler patterns. All of the features delineated in the photographs were then transferred by visual means to the base map. Some positional errors were undoubtedly introduced by this procedure, but it is believed that they are not so large as to compromise the value of the resulting base map.

c. Construction of hydrologic geometry high-water-stage factor map. All sample sites exhibiting a water depth of 91 cm or more were plotted on an overlay fitted to the base map. Each site thus plotted was annotated with the measured depth and with the estimated or recorded depth at the mean maximum stage. Each feature on which such a sample was located was then examined on the air photos, and an interpretation was made as to the extent of water depths of 91 cm or more along that feature. All possible sources of background information, of which a major source was the interpreters' personal experiences with Thailand hydrologic conditions, were invoked to assist in this process. The photos were then examined for features of similar size and configuration that had not been "flagged" by having a sample point located on them. Any such features were also traced off the base map onto the overlay. All features delineated on the overlay were accepted as being those required for portrayal on the high-water-stage map. After the high-water-stage features had been determined, the chosen factors had to be identified and portrayed by class ranges (fig. 9). The key-sort punch cards for the sites plotted for the high water stage were sorted out, and the factor values exhibited at each site were noted. With these data, the air photos were again closely scrutinized in an effort to establish recognition criteria for the various factor value classes. These criteria having been established as well as possible, each selected feature was closely studied, and appropriate codes were used to annotate the overlay with the assigned value classes. Where a discontinuity occurred, an index mark was placed on the feature. Each bank of the streams and canals was

treated individually, and it was noted[5] that discontinuities rarely occurred at the same place on both banks. When all notations were complete, the factor value classes along each discrete segment of bank (i.e. the segment between index lines marking discontinuities) were coded according to the numerical unit codes given in fig. 9. The order was as given in fig. 9; thus, a bank exhibiting a contact approach angle of 150 deg, a step height of 76 cm, a position of step base 51 cm below water level, and a water depth of 122 cm would be characterized by the code 2331.

d. Construction of hydrologic geometry low-water-stage factor map. The analytical process for the compilation of these maps was analogous to that used for the high-water-stage maps (subparagraph c above). The only difference, of course, was that the depth of water at the mean minimum water level stage was the controlling criterion. Thus, each feature on which a sample was located that exhibited a water depth of 91 cm or more at mean minimum water level was accepted as being a hydrologic geometry feature at the low water stage. The same interpretive procedures and the same annotation and coding devices used for the high-water-stage factor maps were used for the low-water-stage factor maps. It is apparent that many features classified as hydrologic geometry features at high water stage were reclassified as surface geometry features at low water stage. Furthermore, even in those instances where the feature remained in the hydrologic geometry category, there were many features in which every factor value class changed. This occurred because the interpretation of contact approach angle, step height, and the position of step base is dependent upon the position of the water level with respect to the bank; on many complexly configured banks, even a modest change in water level will result in completely different values for those factors that describe bank configuration.

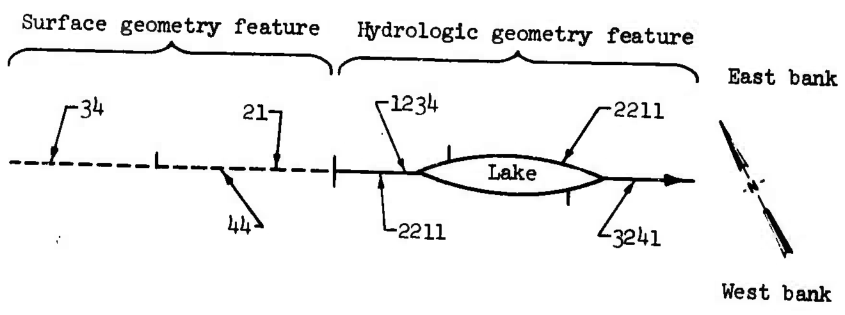
e. Construction of linear surface geometry low-water-stage factor map. The base map incorporates all features described by the hydrologic geometry field teams. Thus, the surface geometry low-water-stage features could be identified by abstracting from the base map all of those features identified as hydrologic geometry low-water-stage features. This process was accomplished by placing the hydrologic geometry low-water-stage map over the base map, placing an overlay over both, and drawing on the overlay only those features not covered by the hydrologic geometry low-water-stage map. The process of interpreting for the factor value classes was the same as that used for the hydrologic geometry factors, except of course that the

interpretations were made for the surface geometry factors (fig. 9). Symbol assignment and annotation procedures were also analogous.

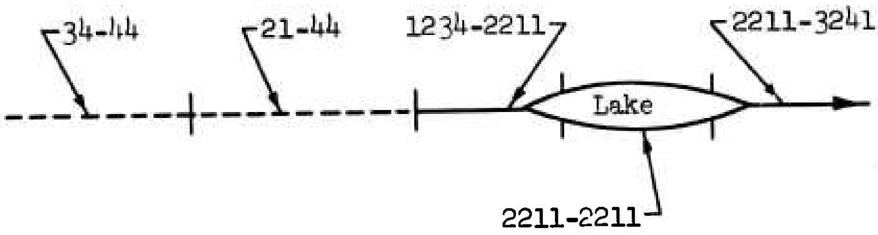
f. Construction of the linear surface geometry high-water-stage factor map. A process analogous to that used for the construction of the surface geometry low-water-stage maps was used to construct the surface geometry high-water-stage factor maps. The map on which all hydrologic geometry high-water-stage features had been delineated was fitted over the base map, and a third sheet was overlaid on the two. All features on the base map not covered by the features on the hydrologic geometry high-water-stage map were traced onto the overlay; all of the features thus transferred are linear surface geometry high-water-stage features. The process of interpreting for factor values was the same as that used for the surface geometry low-water factors. Symbol assignment and annotation procedures were identical.

g. Compilation of combined hydrologic geometry and linear surface geometry factor-family maps. The compilation process for combined hydrologic and linear surface geometry factor-family maps is as follows:

(1) The hydrologic geometry high-water-stage (HG-HW) factor maps and the surface geometry high-water-stage (SG-HW) factor maps are exclusive; that is, there is no overlap of features, but together they incorporate all linear features that are to be considered. These two factor maps were combined, and a single summary high-water-stage map was traced. All features were assumed to have a west and an east bank. The west bank is the one encountered first by a vehicle traveling in an easterly direction (azimuth 0 to 180 deg measured counterclockwise), and conversely the east bank is the one encountered first by a vehicle moving in a westerly direction (azimuth 180 to 360 deg). All features, including those shown with a double line on the base maps, were treated in this way. Each feature was followed carefully, and the code combinations for each segment were recorded. On the factor maps, each bank was classified separately, as indicated on the stylized diagram below:

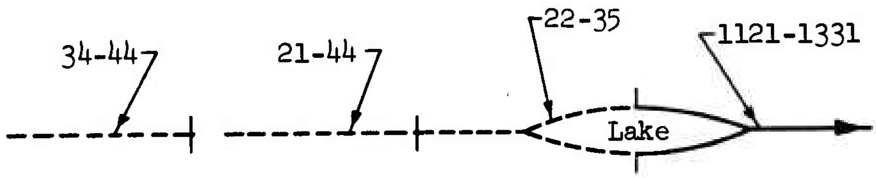


However, on the combined map the codes for both banks were combined into a single symbol combination, as illustrated below:

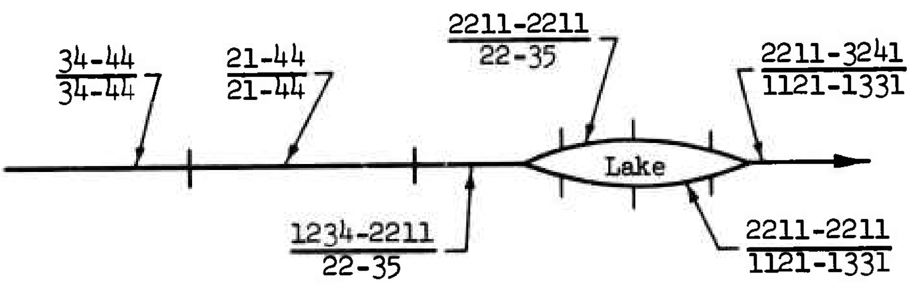


The digit array to the left of the hyphen is the code for east bank conditions, and that to the right of the hyphen is for west bank conditions.

(2) The hydrologic geometry low-water-stage (HG-LW) factor maps and the surface geometry low-water-stage (SG-LW) factor maps are also exclusive, and were combined in the same manner as described for the high-water-stage maps. For the same stylized feature illustrated above, the resulting combined diagram would be:



(3) The two compilations described above (i.e. the high-water-stage maps and the low-water-stage maps) were then combined, and a final compilation was made. The diagram resulting from the synthesis of the two maps for the stylized feature previously illustrated is shown below:



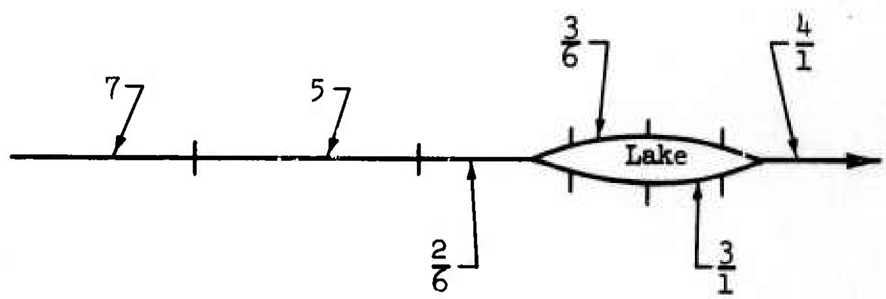
Note that the numerator of the fraction is the annotation of the high-water conditions, and the denominator identifies the low-water-stage conditions. All existing combinations were then on the final map.

(4) In areas on the final map where hydrologic geometry

and linear surface geometry features were close together, it became impractical to use the long strings of symbols illustrated previously. Accordingly, a simplified map symbol system was devised. The symbols were first divided into hydrologic geometry and surface geometry groups; this was simple and direct, because the former are all 4-digit symbols and the latter are all 2-digit groups. Both of the resulting lists of symbols were then placed in a convenient order by arranging them in numerical sequence. Thus, from the illustration on the previous page, two lists of numbers were obtained:

Hydrologic Geometry Symbols	Assigned Map Identification No.	Surface Geometry Symbols	Assigned Map Identification No.
1121-1331	1	21-44	5
1234-2211	2	22-35	6
2211-2211	3	34-44	7
2211-3241	4		

Then, a map identification number was assigned to each, as illustrated above. A simple numerical sequence was used. This greatly simplifies the problem of placing all the required information on the map. For the map example used above, the result was:



Note that in those instances where the numerator and denominator are identical for the surface geometry features, only one number is used. Thus, the absence of a fraction indicates that the feature is a surface geometry feature at both high and low water stages.

51. A total of 1004 combinations of factor value classes occur in all six study areas, of which 633 (map units 1-633) refer to hydrologic geometry features, and 371 (map units 635-1005) describe linear surface geometry features. In the map folio[5] the combined legend, listing every combination found in any of the six study areas and their assigned map

identification number, is printed on the page facing the hydrologic geometry maps. The hydrologic geometry factor-family maps of the six study areas are on base sheets at a scale of 1:50,000 taken from the AMS Series L708. The limits of these maps do not in all instances coincide with those of the AMS sheets because new base sheets were made, where needed, to reduce the number of partially mapped sheets (fig. 11). These limit changes were in most cases a matter of shifting the latitude or longitude 5 or 10 deg from those of the AMS sheets. Preparation of new base sheets resulted in a reduction of the total number of base sheets covering the six study areas from 32 to 25. An example of a portion of a hydrologic geometry factor-family map of the Lop Buri study area (LB III sheet) and the accompanying legend are shown in fig. 12. Since only a portion of the map is shown, all combinations included in the legend do not occur on the map segment. In fact the legend shown is only a partial legend.

52. It should be noted that the ground control consisted of 554 sample points about equally distributed among the six primary study areas. Thus, the sample density was only about one per 16 km^2. In addition, the sample points were concentrated along roads and motorable trails, so that large numbers of features, readily noted on maps and air photos, were not sampled at all. Interpretation of the subtle configurations of bank and bottom in such features was very difficult indeed, and the results are probably much less reliable than those from sites where ground control was available.

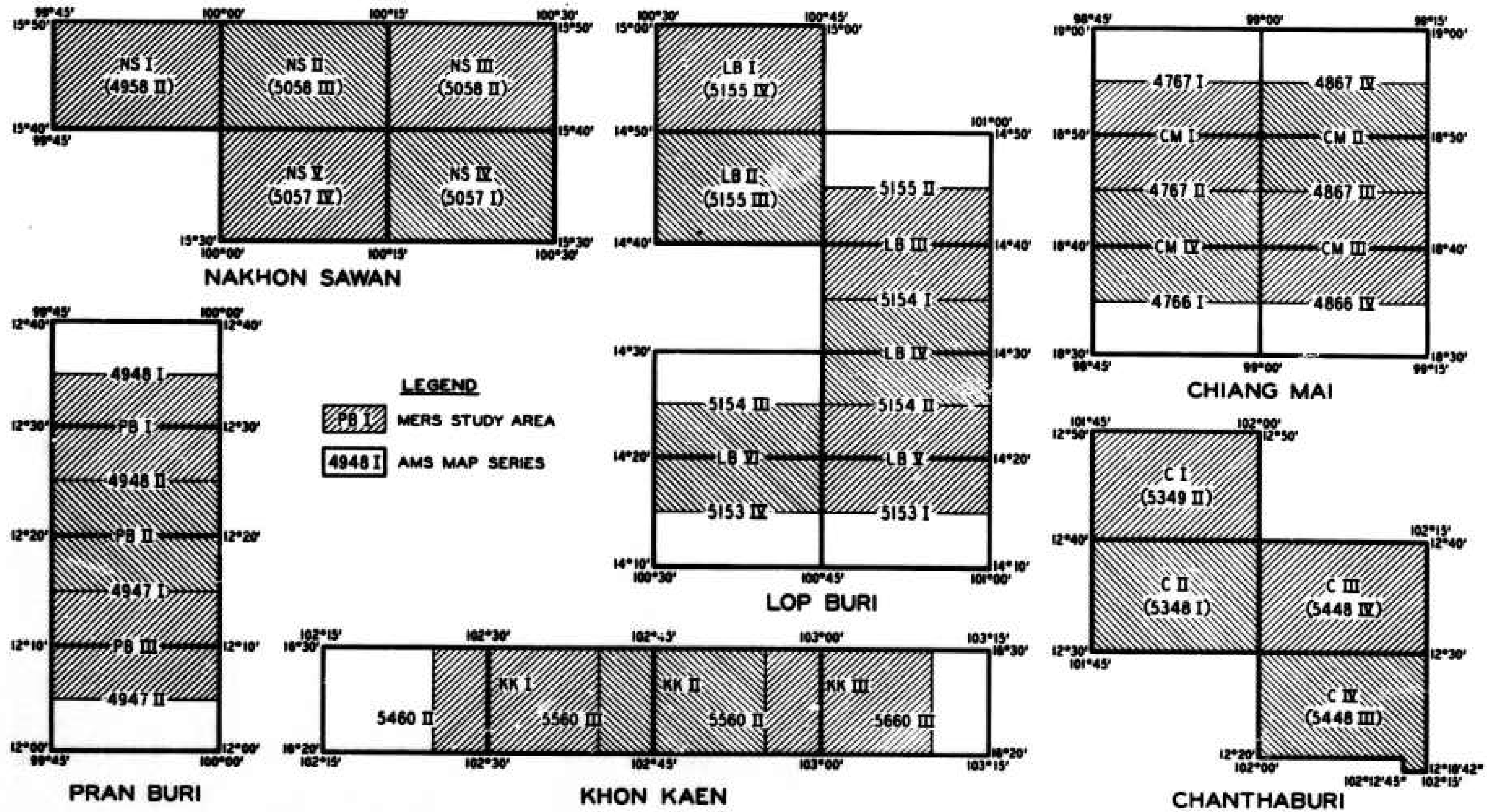


Fig. 11. Relation of MERS and AMS quadrangles

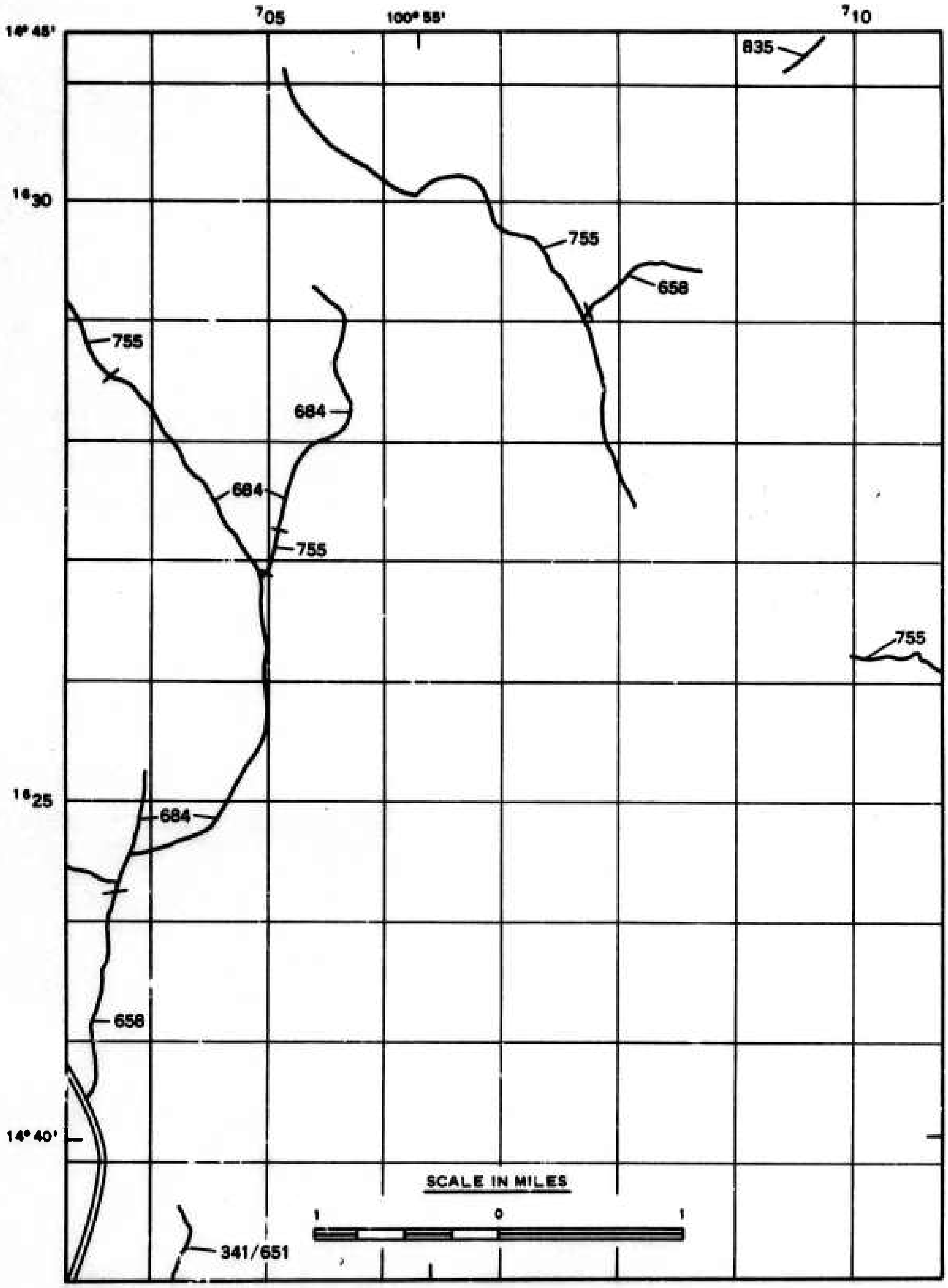


Fig. 12. Hydrologic geometry map of a portion of LB III in the Lop Buri study area (sheet 1 of 2)

LEGEND

Map Unit	Hydrologic Geometry						
	West Bank			East Bank			WD
	AA	SH	PB	AA	SH	PB	
[illegible]	2	5	9	2	X	X	2
[illegible]	2	5	9	2	5	9	1
[illegible]	2	5	9	3	X	X	2
[illegible]	3	X	X	1	X	X	1
[illegible]	3	X	X	1	X	X	2
[illegible]	3	X	X	1	5	2	1
[illegible]	3	X	X	2	X	X	1
[illegible]	3	X	X	2	X	X	2
[illegible]	3	X	X	2	2	4	1
[illegible]	3	X	X	2	2	5	1
[illegible]	3	X	X	2	2	5	2
[illegible]	3	X	X	2	3	2	2
[illegible]	3	X	X	2	3	3	2
[illegible]	3	X	X	2	3	4	1
[illegible]	3	X	X	2	3	5	2
[illegible]	3	X	X	2	3	6	2
[illegible]	3	X	X	2	4	2	1
[illegible]	3	X	X	2	5	2	2
[illegible]	3	X	X	2	5	5	1
[illegible]	3	X	X	2	5	6	1
[illegible]	3	X	X	3	X	X	1
[illegible]	3	X	X	3	X	X	2
[illegible]	3	X	X	3	2	3	1
[illegible]	3	X	X	3	2	4	1
[illegible]	3	X	X	3	3	4	2
[illegible]	3	X	X	3	3	5	2
[illegible]	3	X	X	3	4	2	1
[illegible]	3	X	X	3	5	5	2
[illegible]	3	X	X	4	X	X	1
[illegible]	3	X	X	4	X	X	2
[illegible]	3	X	X	4	3	5	2
[illegible]	3	X	X	4	4	2	2
[illegible]	3	X	X	4	5	5	2
[illegible]	3	X	X	4	5	6	2
[illegible]	3	X	X	4	5	7	2
[illegible]	3	1	5	1	3	7	1
[illegible]	3	1	5	2	X	X	2
[illegible]	3	1	5	2	1	5	1
[illegible]	3	1	5	3	1	5	1
[illegible]	3	1	5	3	1	5	2
[illegible]	3	2	2	4	3	2	2
[illegible]	3	2	3	1	X	X	1
[illegible]	3	2	3	3	2	3	1
[illegible]	3	2	3	3	2	3	2
[illegible]	3	2	3	3	3	3	1
[illegible]	3	2	3	3	3	3	2
[illegible]	3	2	3	4	3	2	2
[illegible]	3	2	4	1	3	1	2
[illegible]	3	2	4	2	2	5	1
[illegible]	3	2	4	2	3	4	2
341	3	2	4	3	2	4	1
[illegible]	3	2	4	3	2	4	2
[illegible]	3	2	4	4	2	3	1
[illegible]	3	2	4	4	2	4	1
[illegible]	3	2	4	4	2	6	1
[illegible]	3	2	4	4	3	4	1
[illegible]	3	2	4	4	4	3	1

Map Unit	Surface Geometry					
	West Bank			East Bank		
	EA	IA	SH	IA	EA	SH
[illegible]	6	2	4	2	6	4
[illegible]	6	2	5	3	9	5
[illegible]	6	2	6	4	8	6
[illegible]	6	3	4	1	8	4
[illegible]	6	3	4	3	6	4
[illegible]	6	3	5	3	6	5
[illegible]	6	3	5	3	8	5
[illegible]	6	3	5	5	6	5
[illegible]	6	3	6	3	6	6
[illegible]	6	3	6	3	8	6
[illegible]	6	3	7	2	9	7
[illegible]	6	4	3	4	6	3
[illegible]	6	4	3	4	7	3
[illegible]	6	4	4	3	7	4
649	6	4	4	4	6	4
[illegible]	6	4	4	4	7	4
651	6	4	4	5	6	4
[illegible]	6	4	5	1	8	5
[illegible]	6	4	5	1	8	6
654	6	4	5	3	6	5
[illegible]	6	4	5	3	8	5
[illegible]	6	4	5	3	9	5
657	6	4	5	4	6	5
658	6	4	5	4	7	5
[illegible]	6	4	5	4	8	5
[illegible]	6	4	6	2	6	6
[illegible]	6	4	6	2	9	6
[illegible]	6	4	6	4	6	6
[illegible]	6	4	6	4	8	6
[illegible]	6	4	7	1	9	7
[illegible]	6	4	7	2	8	7
[illegible]	6	4	7	2	9	7
[illegible]	6	4	7	3	9	7
[illegible]	6	4	7	4	6	7
[illegible]	6	4	8	2	8	8
[illegible]	6	4	8	3	6	8
[illegible]	6	4	8	3	9	8
[illegible]	6	4	8	4	6	8
673	6	5	3	5	6	3
[illegible]	6	5	4	2	9	4
[illegible]	6	5	4	3	8	4
[illegible]	6	5	4	4	6	4
[illegible]	6	5	4	4	7	4
[illegible]	6	5	4	4	8	4
679	6	5	4	5	6	4
[illegible]	6	5	5	2	8	5
[illegible]	6	5	5	2	9	5
[illegible]	6	5	5	3	8	5
[illegible]	6	5	5	4	7	5
684	6	5	5	5	6	5
[illegible]	6	5	5	4	7	5
[illegible]	6	5	6	5	6	6
[illegible]	6	5	6	4	7	6
[illegible]	6	5	6	5	9	6
[illegible]	6	5	7	2	8	7
[illegible]	6	5	7	4	7	7
[illegible]	6	5	7	4	8	7
[illegible]	6	5	7	5	6	7

Map Unit	Surface Geometry					
	West Bank			East Bank		
	EA	IA	SH	IA	EA	SH
[illegible]	7	4	5	3	7	5
[illegible]	7	4	5	3	8	5
[illegible]	7	4	5	3	9	5
[illegible]	7	4	5	4	6	5
755	7	4	5	4	7	5
756	7	4	5	4	8	5
[illegible]	7	4	[illegible]	5	6	5
[illegible]	7	4	[illegible]	5	7	5
[illegible]	7	4	6	1	9	6
[illegible]	7	4	6	2	9	6
[illegible]	7	4	6	2	7	6
[illegible]	7	4	6	3	8	6
[illegible]	7	4	6	4	7	6
[illegible]	7	4	6	4	8	6
[illegible]	7	4	6	5	6	6
[illegible]	7	4	6	5	7	6
[illegible]	7	4	7	3	8	7
[illegible]	7	4	7	4	7	7
[illegible]	7	4	7	4	8	7
[illegible]	7	4	7	5	7	7
[illegible]	7	4	8	2	9	8
[illegible]	7	4	8	3	7	8
[illegible]	7	4	8	4	7	8
[illegible]	7	5	3	5	6	3
[illegible]	7	5	3	5	7	3
[illegible]	7	5	4	4	7	4
777	7	5	4	5	6	4
778	7	5	4	5	7	4
779	7	5	5	4	7	5
780	7	5	5	4	8	5
781	7	5	5	5	7	5
[illegible]	7	5	6	4	9	6
783	7	5	6	5	7	6
[illegible]	7	5	6	5	8	6
[illegible]	7	5	7	5	7	7
[illegible]	7	5	8	4	8	8
[illegible]	8	1	5	1	8	5
788	8	1	5	2	8	5
[illegible]	8	1	5	2	9	5
[illegible]	8	1	6	2	8	6
[illegible]	8	1	8	1	8	8
[illegible]	8	2	4	2	8	4
[illegible]	8	2	4	2	9	4
[illegible]	8	2	4	3	7	4
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[illegible]	8	2	4	4	8	4
[illegible]	8	2	4	5	7	4
[illegible]	8	2	5	1	8	5
[illegible]	8	2	5	1	9	3
[illegible]	8	2	5	2	7	5
[illegible]	8	2	5	2	8	5
[illegible]	8	2	5	2	9	5
[illegible]	8	2	5	3	7	5
[illegible]	8	2	5	3	8	5
[illegible]	8	2	5	4	7	5
806	8	2	5	4	9	5
[illegible]	8	2	5	5	6	5
[illegible]	8	2	6	1	8	6

Map Unit	Surface Geometry					
	West Bank			East Bank		
	EA	IA	SH	IA	EA	SH
[illegible]	8	2	6	1	9	6
[illegible]	8	2	6	2	7	6
[illegible]	8	2	6	2	8	6
812	8	2	6	2	9	6
[illegible]	8	2	6	3	8	6
[illegible]	8	2	6	3	9	6
[illegible]	8	2	6	4	7	6
[illegible]	8	2	7	1	9	7
[illegible]	8	2	7	2	8	7
[illegible]	8	2	7	2	9	7
[illegible]	8	2	7	3	8	7
[illegible]	8	2	8	2	8	8
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[illegible]	8	3	3	3	9	3
[illegible]	8	3	4	2	8	4
[illegible]	8	3	4	2	9	4
[illegible]	8	3	4	3	7	4
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[illegible]	8	3	5	2	8	5
[illegible]	8	3	5	2	9	5
[illegible]	8	3	5	3	7	5
835	8	3	5	3	8	5
[illegible]	8	3	5	3	9	5
[illegible]	8	3	5	4	7	5
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[illegible]	8	3	5	5	6	5
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[illegible]	8	3	6	2	9	6
[illegible]	8	3	6	3	7	6
844	8	3	6	3	8	6
[illegible]	8	3	6	3	9	6
[illegible]	8	3	6	4	6	6
[illegible]	8	3	6	4	7	6
[illegible]	8	3	6	4	8	6
[illegible]	8	3	7	2	8	7
[illegible]	8	3	7	3	7	7
[illegible]	8	3	7	3	8	7
[illegible]	8	3	7	3	9	7
[illegible]	8	3	7	4	7	7
[illegible]	8	3	7	5	8	7
[illegible]	8	3	8	1	9	8
[illegible]	8	3	8	2	9	8
[illegible]	8	3	8	3	6	8
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[illegible]	8	3	8	3	9	8
[illegible]	8	3	8	4	8	8
[illegible]	8	3	9	3	8	9
[illegible]	8	4	3	4	8	3
[illegible]	8	4	4	3	9	4
[illegible]	8	4	4	4	7	4
[illegible]	8	4	4	4	8	4
[illegible]	8	4	4	4	9	4

~~43~~ Units not mapped.

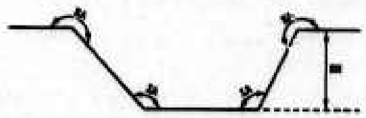
* Features are usually identified by a fraction. Each component of the fraction is a map unit that represents an array of seven symbols or less describing a particular feature. The numerator indicates high-water conditions and the denominator indicates low-water conditions. Features identified by only one map unit contain less than 3 ft of water at all times and are mapped as surface geometry features. Map units 1-633 describe hydrologic geometry features and map units 635-1005 describe surface geometry features. Hydrologic geometry symbols represent class ranges of contact approach angle AA (see Hydrologic Geometry Diagram below), step height SH, position of step base PB referenced to water level, and water depth WD for each bank. Surface geometry symbols represent class ranges of exterior approach angle EA (see Surface Geometry Diagram below), interior approach angle IA, and step height SH for each bank. West bank is the first bank encountered while traversing an area in an easterly direction (i.e. azimuth > 0 to 180 deg) and the east bank is the first bank encountered while traversing an area in a westerly direction (i.e. azimuth > 180 to 300 deg), assuming that the vehicle intersects the feature at a right angle.

† Class ranges for each factor are:

Surface Geometry

Terrain Approach Angle (EA & IA)	
Unit	Range, deg
1	< 100
2	100-< 125
3	125-< 150
4	150-< 165
5	165-< 180
6	180-< 200
7	200-< 210
8	210-< 220
9	≥ 220

Step Height (SH)		
Unit	Range, in.	Range, cm
1	0-4	0-10.16
2	> 4-10	> 10.16-25.40
3	> 10-18	> 25.40-45.72
4	> 18-30	> 43.72-76.20
5	> 30-48	> 76.20-121.92
6	> 48-66	> 121.92-167.64
7	> 66-84	> 167.64-213.36
8	> 84	> 213.36



Hydrologic Geometry

Contact Approach Angle (AA)	
Unit	Range, deg
1	< 143
2	145-155
3	> 155-165
4	> 165-180

Step Height (SH)		
Unit	Range, in.	Range, cm
1	< 12	< 30.48
2	12-< 24	30.48-< 60.96
3	24-< 36	60.96-< 91.44
4	36-48	91.44 - 121.92
5	> 48	> 121.92
x	step absent	step absent

Position of Step Base (PB)		
Unit	Range, in.	Range, cm
1	> 48 (bwl[1])	> 121.92 (bwl)
2	> 36-48 (bwl[1])	> 91.44-121.92 (bwl)
3	> 18-36 (bwl[1])	> 45.72-91.44 (bwl)
4	1-18 (bwl[1])	2.54-45.72 (bwl)
5	at water level	at water level
6	1-12 (awl[2])	2.54-30.48 (awl)
7	> 12-30 (awl[2])	> 30.48-76.20 (awl)
8	> 30-48 (awl[2])	> 76.20-121.92 (awl)
9	> 48 (awl[2])	> 121.92 (awl)
x	step absent	step absent

Water Depth (WD)		
Unit	Range, ft	Range, m
1	3-4.5	0.91-1.37
2	> 4.3	> 1.37

[1] Below water level
[2] Above water level

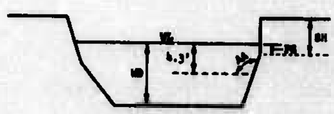


Fig. 12 (sheet 2 of 2)

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

53. Despite the fact that most of the factors significant to cross-country mobility and associated with hydrologic geometry features are too small to be measured at standard air-photo scales (1:15,000, 1:40,000, and 1:50,000), it is still possible to achieve reasonably reliable estimates of the factor values by inference, assuming that a sufficient set of ground control points is available.

54. Some regions in the primary study areas were insufficiently represented by ground control sampling points to permit reliable photo interpretation and mapping. For a regional study, all major terrain types should be represented in the sample array; otherwise extrapolation from measured points becomes extremely tenuous for the unsampled terrain types. Such a balance was not entirely achieved in this study, primarily because of the difficulty of access to the sites. This was especially critical in areas of high-relief terrain.

55. The processes of photo interpretation and the compilation of factor-family maps are both extremely time-consuming. In fact, the expenditures of labor time are so large as to make the procedure practical only for limited areas, assuming present techniques are used.

56. It is technically possible to map those hydrologic geometry factors that significantly affect the cross-country mobility of ground-contact vehicles in such a form that the map units can be used as inputs to an analytical model relating terrain conditions to vehicle speed.[5]

Recommendations

57. It is recommended that ground photographs be used to a greater extent by the field teams responsible for measuring hydrologic geometry factors. Stereopairs should be taken not only of the immediate sites, but of adjacent features, including bank configurations on adjacent reaches, as well. Taken under controlled conditions, such photography can yield

reliable estimates of factor values through standard photogrammetric procedures.

58. It is recommended that a research effort be launched to simplify and mechanize the factor-family map compilation process. Since the process is entirely mechanistic, it should be readily amenable to treatment by automatic data processing machines. It is anticipated that the product of such a data manipulation process would include the drawing of the factor and factor-family maps by a computer-plotter link.

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1. Dornbush, W. K., Jr., "Mobility Environmental Research Study: A Quantitative Method for Describing Terrain for Ground Mobility; Surface Geometry," Technical Report No. 3-726, Volume III, September 1967, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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3. Rula, A. A., et al, "Environmental Factors Affecting Ground Mobility in Thailand; Preliminary Survey," Technical Report No. 5-625, May 1963, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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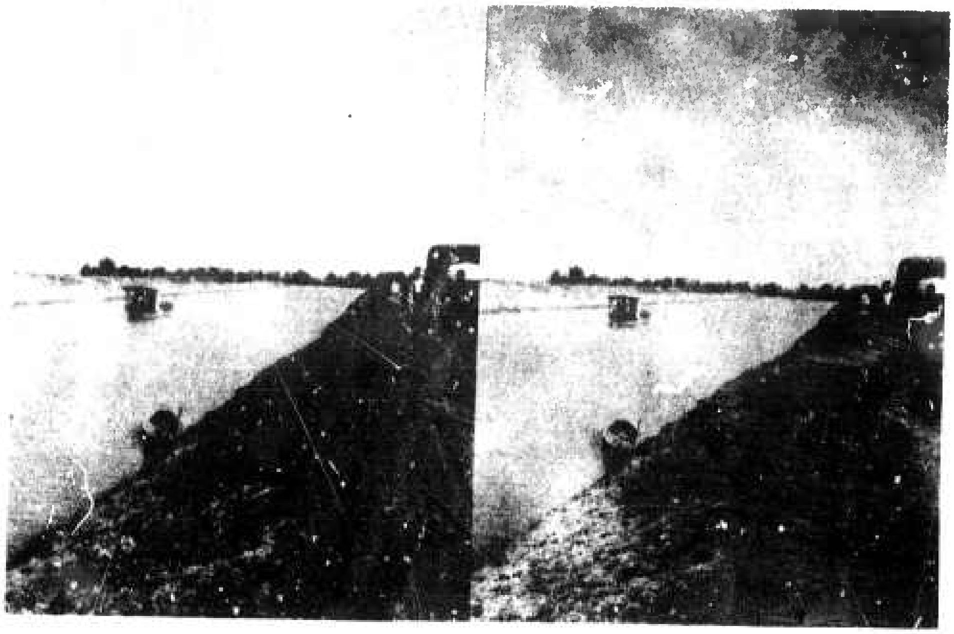
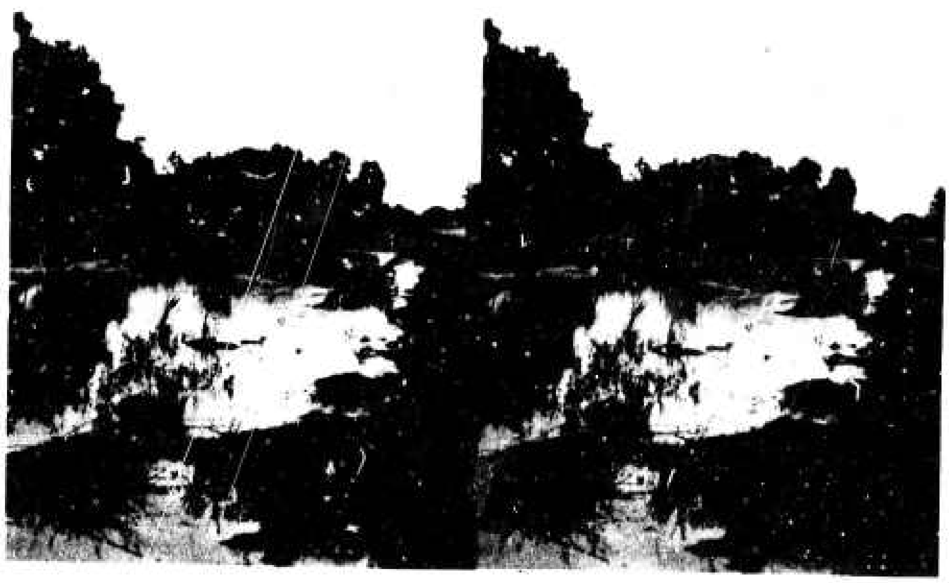
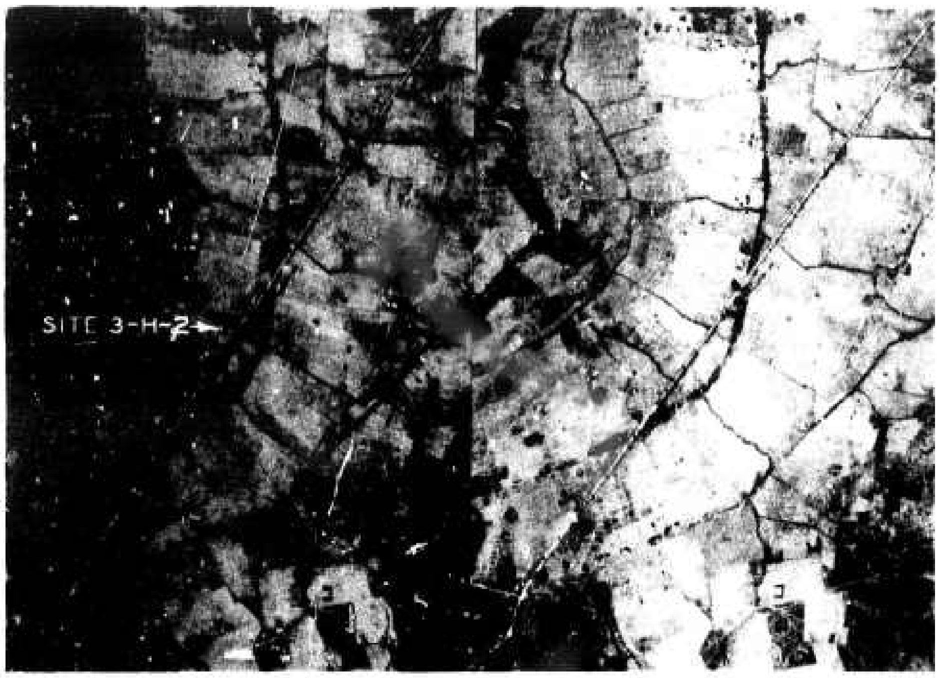


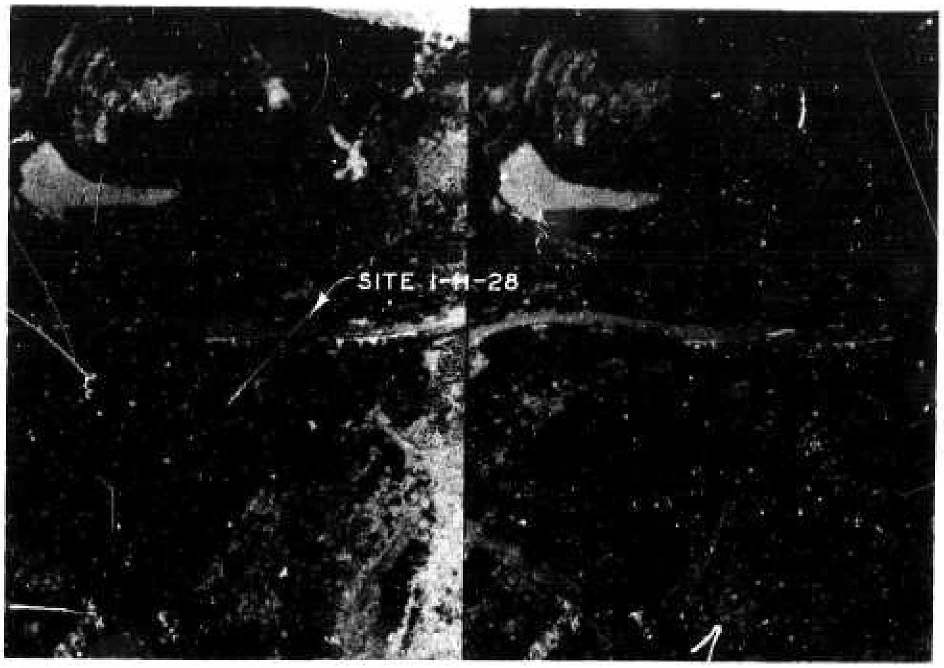
Photograph 1. Stereopair of an irrigation canal at site 2-H-15-7 in the Lop Buri study area



Photograph 2. Stereopair of a borrow pit paralleling the highway at site 5-H-2 in the Khon Kaen study area

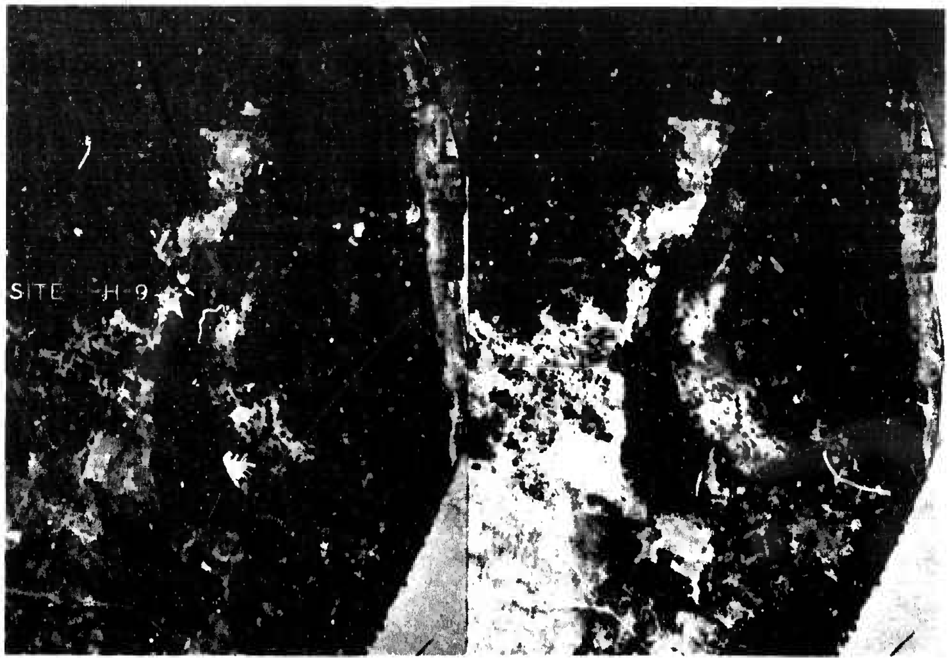


Photograph 3. Stereopair of site 3-H-2 and vicinity in the Chiang Mai study area showing stream patterns that have been changed for irrigation purposes (1:25,000)



Photograph 4. Stereopair of site 1-H-28 and vicinity in the Nakhon Sawan study area showing natural lakes and bends (1:20,000)

Photograph 5. Stereopair of a stream being sampled at site 5-H-25 in the Khon Kaen study area



Photograph 6. Stereopair of site 1-H-9 and vicinity in the Nakhon Sawan study area showing a portion of the Chao Phraya River and a natural lake. Note that the aquatic vegetation visible in photograph 7 is also apparent in this photograph (1:20,000)

Photograph 7. Stereopair of a lake at site 1-H-9 in the Nakhon Sawan study area

APPENDIX A: SUMMARY OF HYDROLOGIC GEOMETRY FIELD DATA AND SITE LOCATION MAPS

NAKHON SAWAN

Table A1

Summary of Hydrologic and Surface Geometry Field Data

Nakhon Sawan

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Step** Height, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Position of Step Base,† in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Water Depth ft: Max Wtr	Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1†† App Angle	1†† Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
1-H-1	4958II	NS I	035465	175	160				24				-24			4	2					195	160	115	230			155	60	4.5
1-H-2	4958I	♦	965571	165	155	165	155	20	90	20	90	-18	-36	+24	0	6	3													
1-H-3	4958I	♦	037607	175	170				60				+12			3.5	1					185	165	140	220					7
1-H-4	4958I	♦	996592	90	165			16				-26				3.5	1	140	26			220	90	165	200					5
1-H-5	4958II	NS I	957421	150	155				32				-36			5.5	1.5					190	150	90	270					6
1-H-6	5057I	NS IV	474239	175	170											5	2.5					210	150	155	190					6
1-H-7	5057I	NS IV	569258													2.5	1.5					190	160	160	185					3
1-H-8	5057I	NS IV	577278	155	175	155	175	72		72		-54		-12		7	3													
1-H-9	5057IV	NS V	193310	165	170	165	165									9	5													
1-H-10	5058III	NS II	159349	165	145	170	165		60		60		-60		0	8.5	4													
1-H-11	5058III	NS II	115374	165	170	170	170	26	30	26	30	-48	-24	-12	+16	6	3													
1-H-12	5058III	NS II	148437	135	100	135	100	102	120	102	120	-54	-48	0	0	24	19													
1-H-13	5058III	NS II	166367	170	155				36				-36			5	2.5					210	165	140	220					6
1-H-14	5057IV	NS V	167257	165	155	125	140	162		48	18	-36		-48	+24	16	8.5													
1-H-15	4958II	NS I	008441	140	160			24	18			-18	-12			3	1					215	150	145	220					4
1-H-16	4958II	NS I	997445	160	160	160	160		24		24		0		+12	5	3													
1-H-17	4958II	NS I	841416	170	135			12	30			-12	-18			3	1.5					210	150	120	240					4
1-H-18	4958II	NS I	854419	140	160			18	24			-18	-12			3.5	0.5	145	20			230	145	90	260					4
1-H-19	4958II	NS I	881409													2	0.5					190	170	145	220					3
1-H-20	4958II	NS I	916427													2	0	150	24			210	150	155	200					3
1-H-21	5057IV	NS V	209322													2	0	160	74			200	150	170	195					2.5
1-H-22	5057IV	NS V	208144	175	175				18				-18			3.5	1.5					215	145	175	185					4
1-H-23	5057I	NS IV	444239													2.5	0	150	30			220	140	170	190					3
1-H-24	5057I	NS IV	344289													2	0.5	160	56			200	160	175	155					2
1-H-25	5057IV	NS V	316295													2.5	1	170	48			210	160	140	220					3
1-H-26	5057IV	NS V	214191	175	165				20				-14			3.5	0.5	140	24			200	160	130	230			155	12	4.5
1-H-27A	4958II	NS I	039456													2	0.5	130	14			210	150	165	200			160	66	2.5
1-H-27B	4958II	NS I	039456													2.5	0	165	72			200	165	130	220			155	12	3
1-H-28	5058III	NS II	286409	130	150	175	165	72		72		-60		+24		18	11													
1-H-29A	4958I	♦	968565													2	0	135	12			220	150	155	200	170	42	160	78	2.5
1-H-29B	4958I	♦	968565													2	0	165	42			200	165	145	220					2.5
1-H-30A	4958I	♦	922627													2	0	166	12			210	150	160	200			90	18	2.5
1-H-30B	4958I	♦	922627													2.5	0.5	160	72			200	90	175	185					2.5
1-H-31A	4958I	♦	901650													2	0					195	165	160	200			150	36	2
1-H-31B	4958I	♦	901650													2	0					210	155	90	270			130	10	2
1-H-32A	4958II	NS I	023474													2	0.5	150	12			270	90	165	190			125	18	2.5
1-H-32B	4958II	NS I	023474													2.5	1	165	48			195	125	90	270			130	16	3.5
1-H-33	5057IV	♦	256311													1.5	0	165	24			190	170	175	185			175	13	2.5
1-H-34	5058III	NS II	114390													1.5	0					185	160	175	190	150	30	130	24	2
1-H-35A	4958II	NS I	975443													2	0.5	120	18			220	140	150	210			155	36	2.5

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.

** A step is a slope change that is >35 deg.

† Position of step base is referenced to water level.

†† For position of numerically designated approach angle and step height see fig. 6.

♦ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

NAKHON SAWAN

Table A1

Summary of Hydrologic and Surface Geometry Field Data

Nakhon Sawan

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg, Max Wtr W	Contact Approach Angle, Max Wtr E	Contact Approach Angle, Min Wtr W	Contact Approach Angle, Min Wtr E	Step** Height, in., Max Wtr W	Step Height, Max Wtr E	Step Height, Min Wtr W	Step Height, Min Wtr E	Position of Step Base,† in., Max Wtr W	Position, Max Wtr E	Position, Min Wtr W	Position, Min Wtr E	Water Depth ft, Max Wtr	Water Depth ft, Min Wtr	Surface Geometry, Critical Approach Angle, deg and Step Height, in.: 1†† App Angle	1†† Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
1-H-1	4958II	NS I	035465	175	160				24				-24			4	2					195	160	115	230			155	62	4.5
1-H-2	4958I	•	985571	165	155	165	155	20	90	20	90	-18	-36	+24	0	6	3													
1-H-3	4958I	•	037607	175	170				60				+12			3.5	1					185	165	140	220					7
1-H-4	4958I	•	996592	90	165			16				-26				3.5	1	140	26			220	90	165	200					5
1-H-5	4958II	NS I	957421	150	155				32				-36			5.5	1.5					190	150	90	270					6
1-H-6	5057I	NS IV	474239	175	170											5	2.5					210	150	155	190					6
1-H-7	5057I	NS IV	569258													2.5	1.5					190	160	160	185					3
1-H-8	5057I	NS IV	577278	155	175	155	175	72		72		-54		-12		7	3													
1-H-9	5057IV	NS V	193310	165	170	165	165									9	5													
1-H-10	5058III	NS II	159349	165	145	170	165		60		60		-60		0	8.5	4													
1-H-11	5058III	NS II	115374	165	170	170	170	26	30	26	30	-48	-24	-12	+16	6	3													
1-H-12	5058III	NS II	148437	135	100	135	100	102	120	102	120	-54	-48	0	0	24	19													
1-H-13	5058III	NS II	166367	170	155				36				-36			5	2.5					210	165	140	220					6
1-H-14	5057IV	NS V	167257	165	155	125	140	162		45	18	-36		-45	+24	16	8.5													
1-H-15	4958II	NS I	008441	140	160			24	18			-18	-12			3	1					215	150	145	220					4
1-H-16	4958II	NS I	997445	160	160	160	160		24		24		0		+12	5	3													
1-H-17	4958II	NS I	841415	170	135			12	30			-12	-18			3	1.5					210	150	120	240					4
1-H-18	4958II	NS I	854419	140	160			18	24			-18	-12			3.5	0.5	145	20			230	145	90	260					4
1-H-19	4958II	NS I	881409													2	0.5					190	170	145	220					3
1-H-20	4958II	NS I	916427													2	0	150	24			210	150	155	200					3
1-H-21	5057IV	NS V	209322													2	0	160	74			200	150	170	195					2.5
1-H-22	5057IV	NS V	208144	175	175				18				-18			3.5	1.5					215	145	175	185					4
1-H-23	5057I	NS IV	444239													2.5	0	150	30			220	140	170	190					3
1-H-24	5057I	NS IV	344289													2	0.5	160	56			200	160	175	185					2
1-H-25	5057IV	NS V	316295													2.5	1	170	48			210	160	140	220					3
1-H-26	5057IV	NS V	214191	175	165				20				-14			3.5	0.5	140	24			200	160	130	230			155	12	4.5
1-H-27A	4958II	NS I	039456													2	0.5	130	14			210	150	165	200			160	66	2.5
1-H-27B	4958II	NS I	039456													2.5	0	165	72			200	165	130	220			155	12	3
1-H-28	5058III	NS II	286409	130	150	175	165	72		72		-60		+24		18	11													
1-H-29A	4958I	•	968565													2	0	135	12			220	150	155	200	170	42	160	78	2.5
1-H-29B	4958I	•	968565													2	0	165	42			200	165	145	220					2.5
1-H-30A	4958I	•	922627													2	0	166	12			210	150	160	200			90	18	2.5
1-H-30B	4958I	•	922627													2.5	0.5	160	72			200	90	175	185					2.5
1-H-31A	4958I	•	901650													2	0					195	165	160	200			150	36	2
1-H-31B	4958I	•	901650													2	0					210	155	90	270			130	10	2
1-H-32A	4958II	NS I	023474													2	0.5	150	12			270	90	165	190			125	18	2.5
1-H-32B	4958II	NS I	023474													2.5	1	165	48			195	125	90	270			130	16	3.5
1-H-33	5057IV	•	256311													1.5	0	165	24			190	170	175	185			175	13	2.5
1-H-34	5058III	NS II	114390													1.5	0					185	160	175	190	150	30	130	24	2
1-H-35A	4958II	NS I	975443													2	0.5	120	18			220	140	150	210			155	36	2.5

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.

** A step is a slope change that is >35 deg.

† Position of step base is referenced to water level.

†† For position of numerically designated approach angle and step height see fig. 6.

• Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A1 (Concluded)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry At East and West Banks: Contact Approach Angle, deg: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Step Height, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Position of Step Base, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Water Depth ft: Max Wtr	Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
1-H-35B	4958II	MS I	975443	90	90			60	60			-60	-60			5.5	2.5	150	24			220	105	120	210					6
1-H-36A	4958II	MS I	069422													2.5	0.5					270	125	160	200			160	78	3
1-H-36B	4958II	MS I	069422													2.5	0.5					200	160	90	270			135	18	3
1-H-37	5057IV	MS V	208241													2.5	0.5	150	36	165	36	200	160	160	200					3
1-H-38	5058III	MS II	185329	175	175											4	1.5	165	32			205	155	170	190					4
1-H-39	5057I	MS IV	519248													2	0	155	36			200	160	170	190					2
1-H-40	5057I	MS IV	418270													2.5	0	155	12			205	155	170	190					3
1-H-41	4958II	MS I	974415													1.5	0					230	130	130	230			130	16	2
1-H-42	4958II	MS I	054432													1.5	0.5	160	16			190	170	125	240			150	16	2
1-H-43	4958II	MS I	022405	175	150				12				-60			5	0.5					200	115	150	190					6
1-H-44	4958II	MS I	012416													1.5	0	160	12			270	90	115	240			150	12	2
1-H-45	4958I	‡	977562													2	0	168	42			190	165	140	230			145	12	2
1-H-46	5057IV	MS V	206192	172	172											4.5	1.5	170	60			190	172	172	190					5

‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

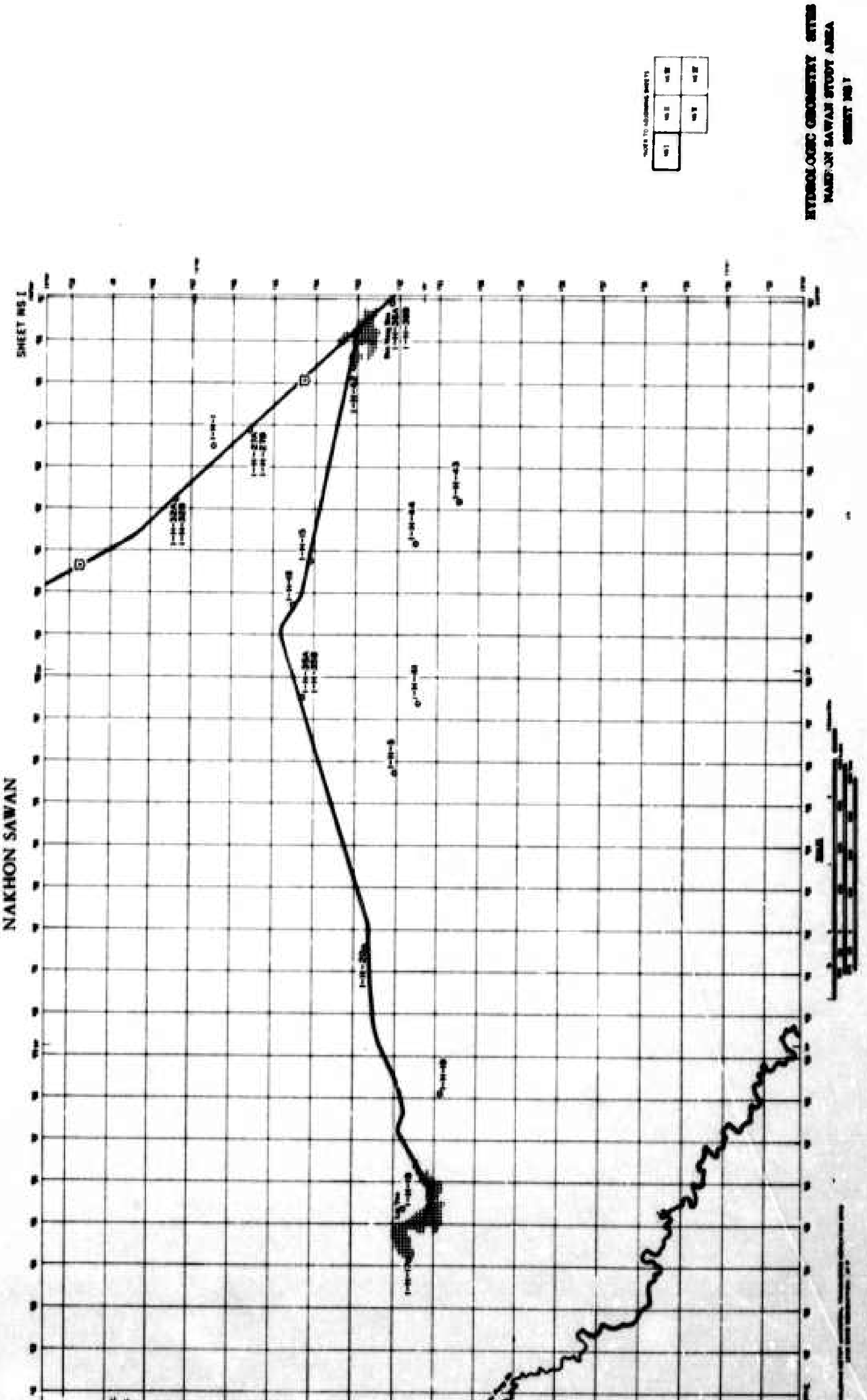
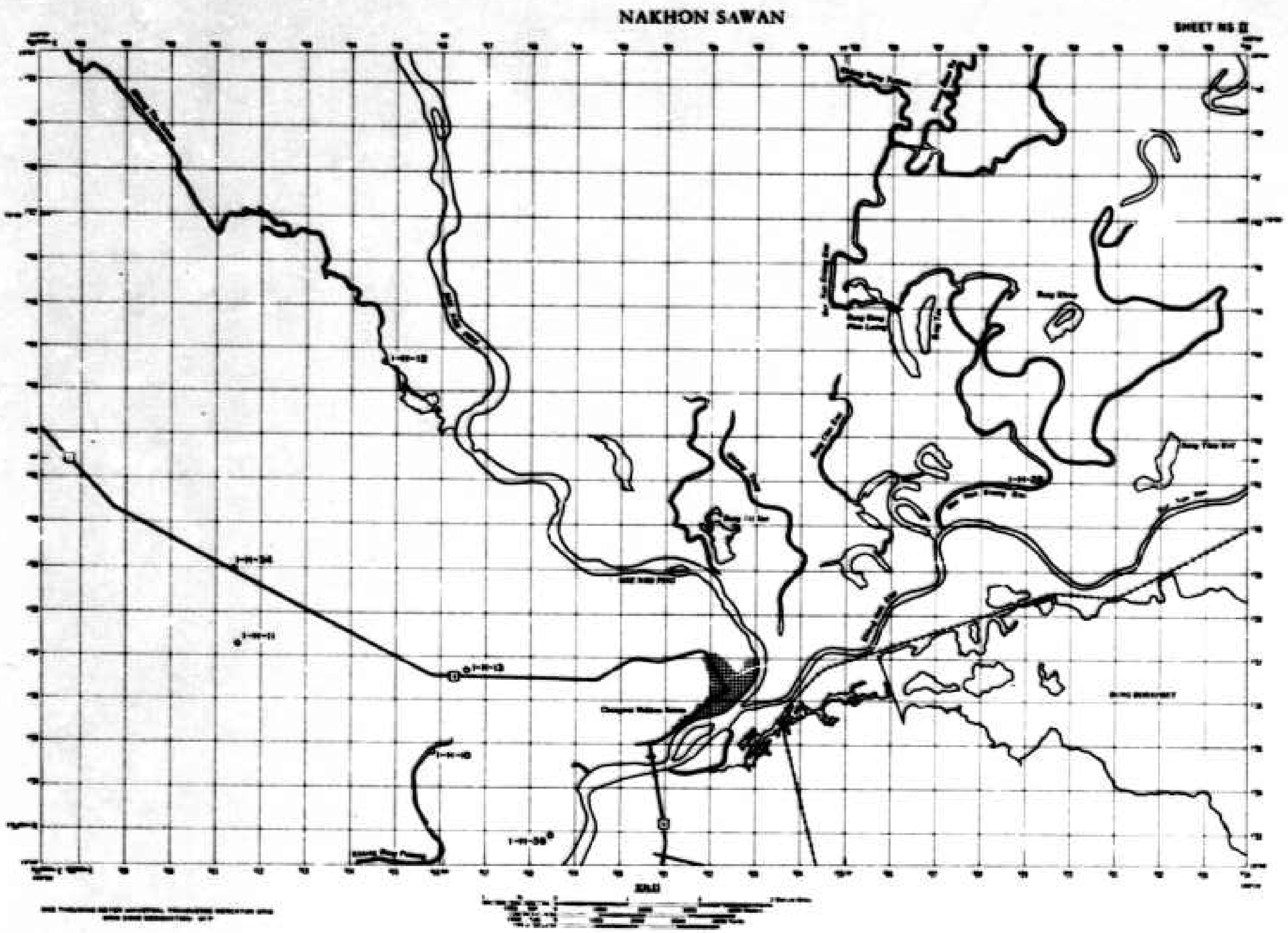


FIG. A1



HYDROLOGIC GEOMETRY SITES
NAKHON SAWAN STUDY AREA
SHEET NS II

FIG. A2

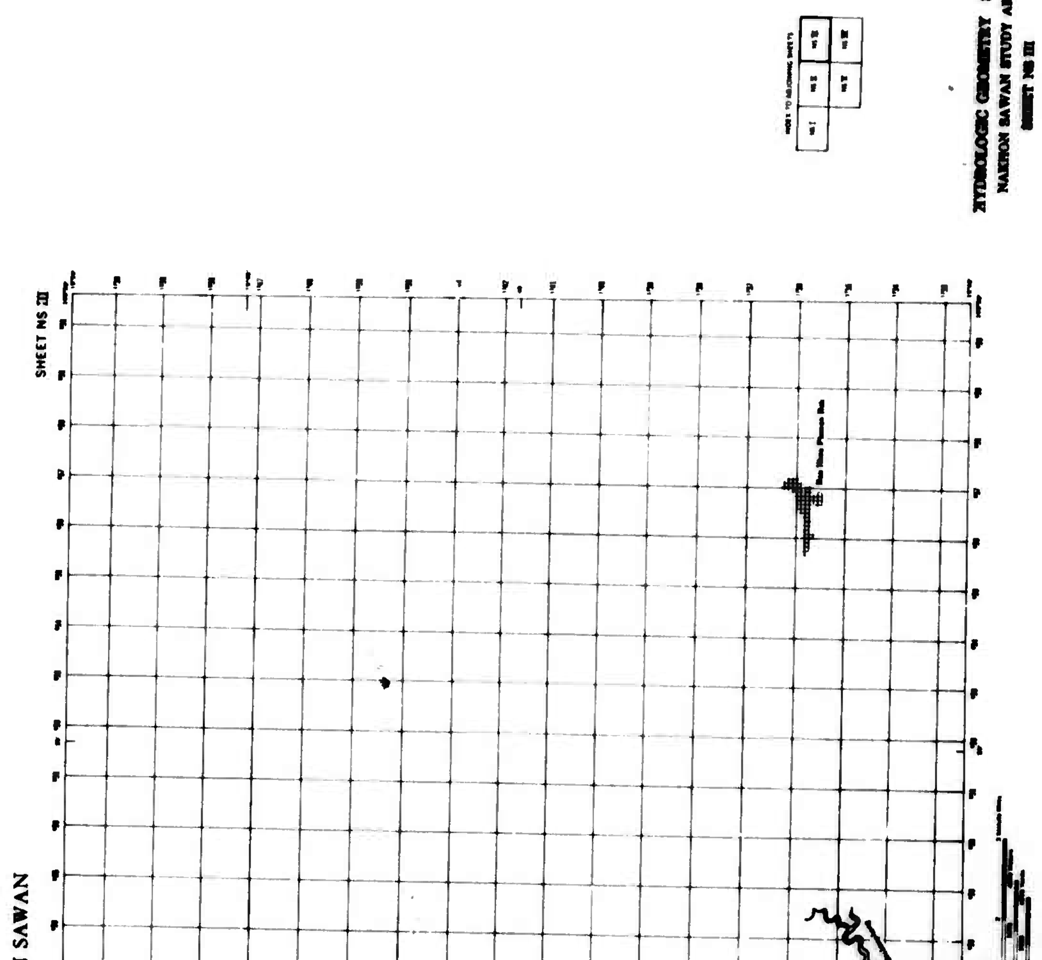

NAKHON SAWAN
SHEET NS III
HYDROLOGIC GEOMETRY SITES
NAKHON SAWAN STUDY AREA
SHEET NS III

FIG. A3

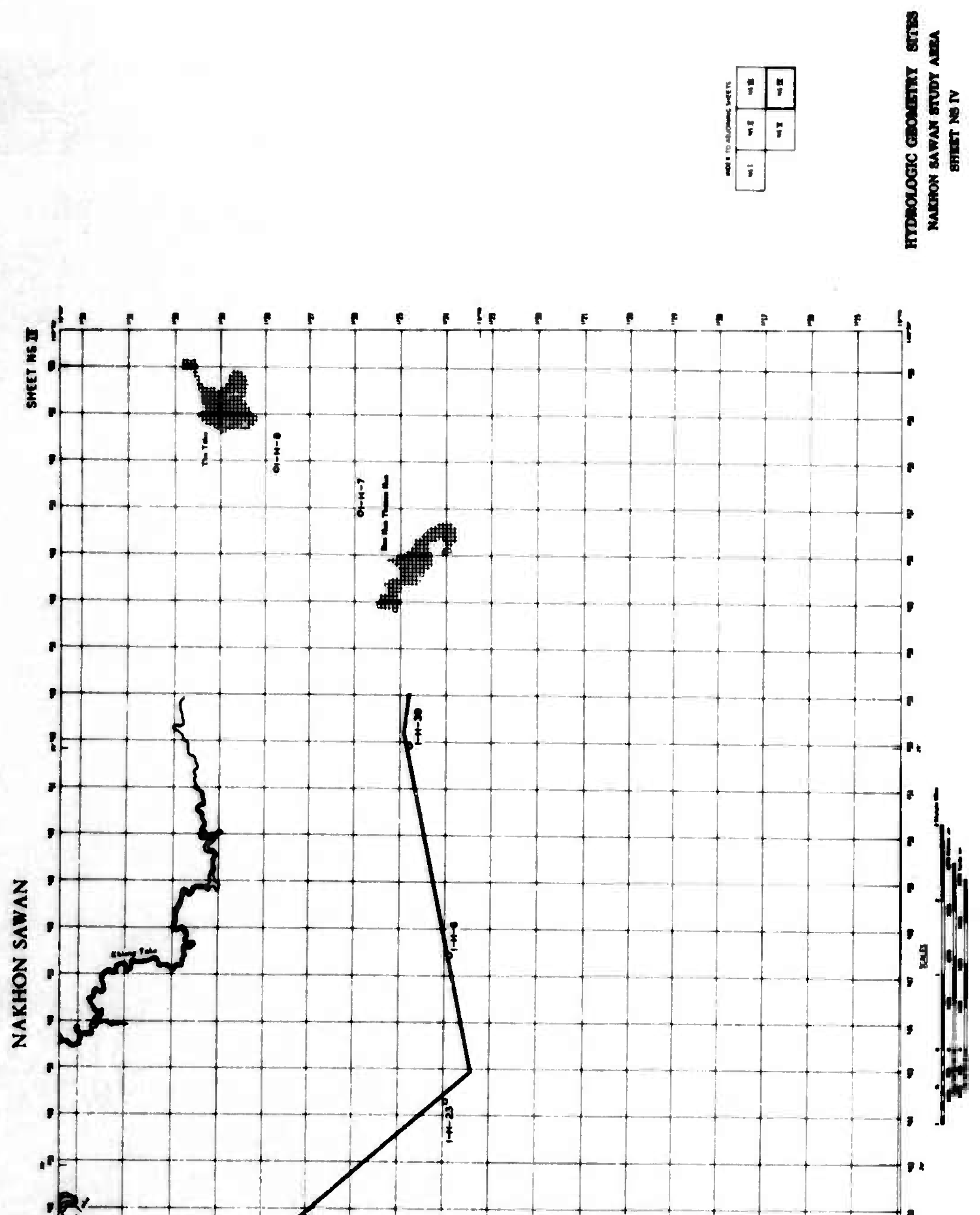
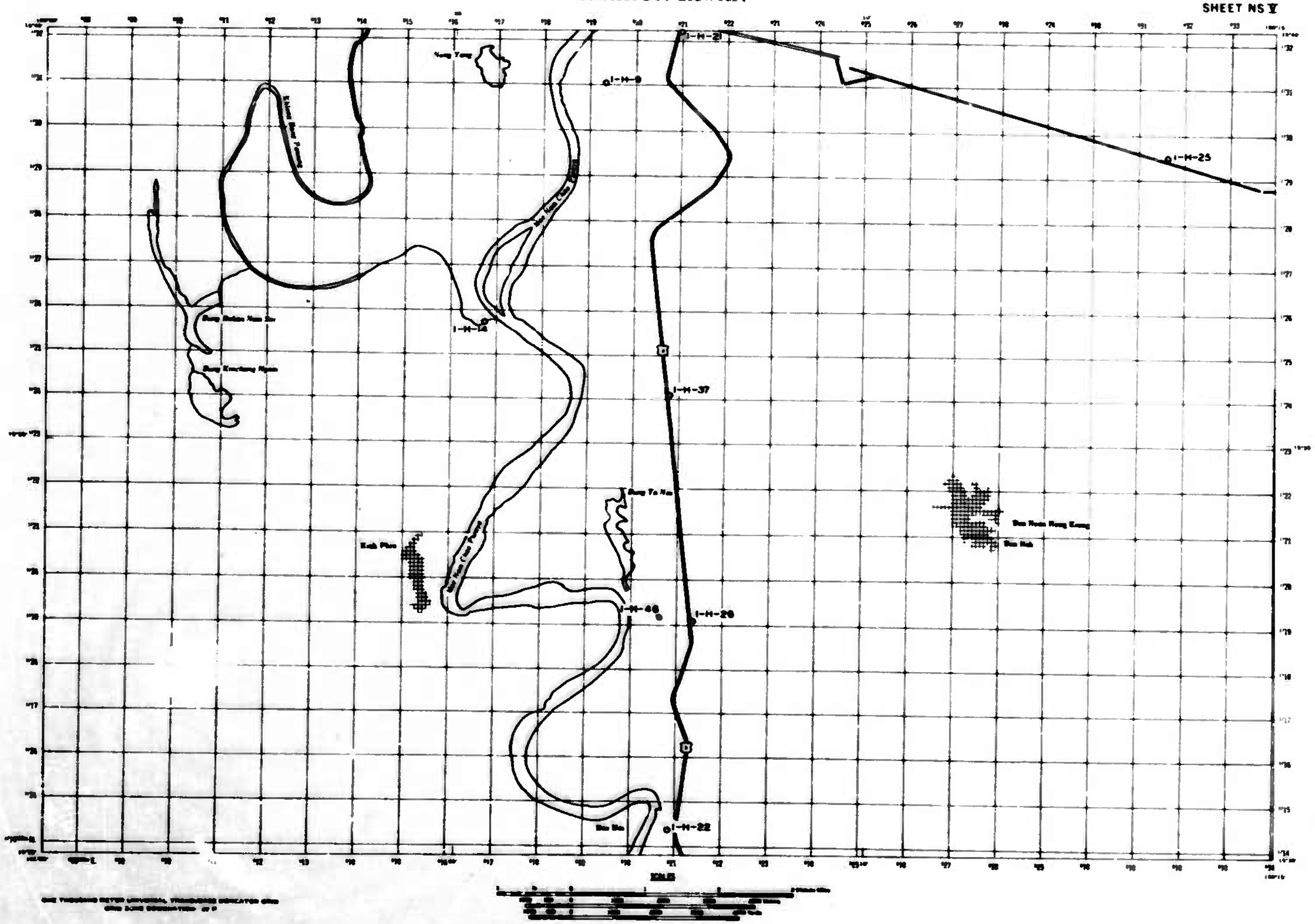

HYDROLOGIC GEOMETRY SITES
NAKHON SAWAN STUDY AREA
SHEET NS IV
NAKHON SAWAN
SHEET NS III
1-H-24
1-H-40
1-H-23
1-H-6
1-H-38
OI-H-7
OI-H-8

FIG. A4

NAKHON SAWAN

SHEET NS V



HYDROLOGIC GEOMETRY SITES
NAKHON SAWAN STUDY AREA
SHEET NS V

FIG. A5

LOP BURI

Table A2

Summary of Hydrologic and Surface Geometry Field Data

Lop Buri

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Step** Height, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Position of Step Base,† in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Water Depth ft: Max Wtr	Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1†† App Angle	1†† Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
2-H-1	5154II	LB V	971881													2	0	170	24			235	120	110	190			175	19	3
2-H-2	5155III	LB II	786364	140	168				12				-12			3	1	125	15	160	15	270	168	145	195					3
2-H-3	5155III	LB II	804357													1	0					215	155	175	185					1
2-H-4	5155III	LB II	834357	140	100			12				0				8	2					255	140	150	195					9
2-H-5	5154I	LB IV	075090	Sinkhole, not used																										
2-H-6	5154I	LB III	034201	170	155			36	30			-30	-30			5	1					255	105	135	230					5
2-H-7	5153I	‡	037832	155	165			42					-24			3	1					225	155	155	220			135	28	3
2-H-8	5154I	LB IV	075092	Sinkhole, not used																										
2-H-9	5154I	LB IV	072095	Sinkhole, not used																										
2-H-3-1A	5154I	LB IV	962092													2	0	120	14			235	115	90	220					3
2-H-3-1B	5154I	LB IV	962092	175	170			30				-22				3	0					190	170	100	245			155	20	4
2-H-3-2	5154I	LB IV	903097	153	110	160	165			32	93			+14	+72	20	6													
2-H-3-3	5154I	‡	901100	No data																										
2-H-4-1	5154I	LB III	907133	150	155	175	175									10	5													
2-H-4-2	5155III	LB II	880255	125	110			24				-16				4.5	0	170	6	155	12	240	135	115	250	175	30	160	40	4.5
2-H-5-1	5153I	‡	970811													2	0	160	27			205	150	120	220			130	24	3
2-H-5-2	5153I	‡	967785	165	130	165	165	30		30	34					11	4													
2-H-5-3	5154III	‡	664995	150	165	160	168									8	4													
2-H-6-1	5155IV	LB I	718476	170	90			36				-18				3	2					260	105	105	260			110	24	5
2-H-6-2	5155IV	LB I	721476	155	165	175	170	28	48	28	48	0	-6	+57	+52	12	7													
2-H-6-3A	5155III	LB II	617388	160	170			15	22			+64	-18			3	0					240	170	160	240					3
2-H-6-3B	5155III	LB II	617388	115	120											3	0					195	125	125	200			173	16	4
2-H-6-3C	5153III	LB II	617388													2	0					210	140	173	195					2
2-H-6-4	5155III	LB II	632381	145	168											7	0					190	110	125	200					8
2-H-6-5	5155III	LB II	654375	170	160			128	28			-12	-46			5	0					220	120	160	255					14
2-H-6-6A	5155III	LB II	721375	175	175											5	2					195	165	170	195					6
2-H-6-6B	5155III	LB II	721375	170	145			28				0				4.5	2					235	140	145	190					5
2-H-7-1	5154I	LB IV	103057	160	100			78				0				10	1					260	135	115	188					10
2-H-7-2	5154I	LB IV	100075	140	170	168	175									10	3													
2-H-7-3	5154I	LB IV	117117	120	150	140	160		42	216	42		0	+16	+77	18	12													
2-H-7-4	5154I	LB IV	081118	158	165											20	0					220	140	140	193					28
2-H-7-5	5154I	‡	135142	No data																										
2-H-8-1	5154II	LB V	131885	165	140			14	36			0	-33			5	1	120	18			250	150	140	270			135	6	6
2-H-14-1A	5154II	LB V	030932													2	0	140	32			200	140	130	230					3
2-H-14-1B	5154II	LB V	030932													2	0					235	135	130	230					2
2-H-14-2	5154II	LB V	021932	90	90	90	100									7	3													
2-H-14-3	5154II	LB V	966944	160	165			20	36			-12	-24			4	1	120	24			240	115	160	260			140	15	5
2-H-14-4	5154II	LB V	925942	168	160	175	168									13	5													
2-H-14-5	5154II	LB IV	909948	160	150			18	24			-9	-18			5	1	170	24			195	160	140	250			90	20	7
2-H-14-6	5154II	LB IV	903953	150	145	160	150	36		36		0		+102		13	5													

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.

** A step is a slope change that is >35 deg.

† Position of step base is referenced to water level.

†† For position of numerically designated approach angle and step height see fig. 6.

‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A2 (Continued)

Site No.	AMS Map Sheet	MEGS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Wtr V	Max Wtr E	Min Wtr V	Min Wtr E	Step Height, in.: Max Wtr V	Max Wtr E	Min Wtr V	Min Wtr E	Position of Step Base, in.: Max Wtr V	Max Wtr E	Min Wtr V	Min Wtr E	Water Depth ft: Max Wtr	Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
2-H-14-7	5154III	*	857977	175	175				24				-10			5	2					200	160	155	210					5
2-H-14-8	5154III	*	855972	No data																										
2-H-14-9	5154III	*	853969	No data																										
2-H-14-10	5154III	*	882967	170	165			28	18			-28	-12			6	1	170	22			210	100	165	195			165	24	6
2-H-14-11	5154II	LB IV	891961	105	150											3	0	115	17			190	150	105	190			100	24	[illegible]
2-H-14-12	5154II	LB V	939920	155	110			15				-36				5	2					200	120	150	225					5
2-H-14-13	5154II	*	936921	No data																										
2-H-15-1	5153I	*	112824													6	4													
2-H-15-2	5153I	*	101817	165	160	165	160	36	72	36	72	-18	-6	+18	+30	7	4													
2-H-15-3	5153I	*	044788	No data																										
2-H-15-4	5153I	*	044752	No data																										
2-H-15-5	5153I	*	044753	165	150	165	160		36		36		-24		+22	10	4													
2-H-15-6	5153I	*	044760	No data																										
2-H-15-7	5153I	*	044805	155	155	150	160		24	36				0	0	15	8													
2-H-16-1	5153IV	*	845750	145	130											3	1	155	18			240	130	145	210					3
2-H-16-2A	5153IV	LB VI	832766	165	150			24				+15				5	1					215	150	160	200	135	24	150	60	7
2-H-16-2B	5153IV	LB VI	832766	155	155											6	0	140	24			220	155	155	195			150	58	7
2-H-16-2C	5153IV	LB VI	832766	130	160			36				-48				5	1	155	72	150	58	205	160	130	230					4
2-H-16-3A	5153IV	LB VI	819785	165	175											3	0					185	165	175	210			160	96	5
2-H-16-3B	5153IV	LB VI	819785	155	170											2.5	0	155	108			200	155	170	190					3
2-H-16-4	5153IV	LB VI	816799	150	160											8	4													
2-H-16-5	5154III	LB VI	686879	160	135				12				-48			4	1.5					200	135	150	200					8
2-H-16-6	5154III	LB VI	659911	170	175	166	175									8	5													
2-H-16-7	5154III	LB VI	652926	175	175											6	1					200	162	170	185					10
2-H-16-8	5154III	LB VI	640933	165	165			18				-48				7	2					195	165	140	240					7
2-H-16-9	5154III	*	621946	175	175											3	1					190	170	150	210					4
2-H-16-10	5154III	*	672874	No data																										
2-H-20-1	5154III	*	659953	115	115	155	175	42	30	42	30	-60	-72	-12	-24	7.5	3.5													
2-H-20-2	5154III	*	712910	No data																										
2-H-20-3	5154III	LB VI	723903	175	170	175	170		24		24		-24		-36	5.5	3													
2-H-20-4	5154III	LB VI	726888	170	150	170	175									12	5													
2-H-20-5	5154III	LB VI	734875	90	175	170	170	60		60		-72		+6		11.5	5													
2-H-20-6	5154III	LB VI	709660	155	140	155	140		36		36		-72		-24	7.5	3.5													
2-H-20-7	5153IV	LB VI	753846	170	155											3	1					200	155	165	195					4
2-H-21-1	5153IV	*	872748	165	170	165	170	30	36	30	36	-18	-30	+12	-6	6	4													
2-H-21-2	5153I	*	905757	165	160	175	170			16					-16	10	5													
2-H-21-3	5153I	*	947794	170	170											5	1.5					190	170	165	190					12
2-H-21-4	5153I	*	973789	158	140	170	175		54		54		-54		0	12	8													
2-H-21-5	5153I	*	986834													2.5	0	145	30			220	140	155	220			140	24	4
2-H-21-6	5153I	*	025844	140	155	140	155	48	48	48	48	-36	-36	0	0	7	3													
2-H-21-7	5153I	*	025845	No data																										
2-H-21-8	5153I	*	027848	No data																										
2-H-21-9	5153I	*	025845	No data																										
2-H-21-10	5153I	*	023848	No data																										
2-H-22-1	5154II	LB V	065856	165	150			24	44			-24	+58			3.5	1	135	70			230	130	160	210			130	10	4
2-H-22-2	5154II	LB V	006857													2	0	140	28			195	160	160	185			135	24	2
2-H-22-3	5154II	LB V	012864	165	175											4.5	2	160	25			220	150	165	195					5
2-H-22-4	5154II	LB IV	061006													2	0			160	78	250	110	125	240			130	6	2
2-H-22-5	5154I	LB IV	044077	175	115	160	1?5	48	60		48	0	+12		0	11	4													
2-H-22-6	5154I	LB IV	969097	175	160	175	150	12	14	12	14	-48	-60	-12	-26	7	4													

(Continued)

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A2 (Concluded)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Step Height, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Position of Step Base, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Water Depth ft: Max Wtr	Min Wtr
2-E-25-1	5155IV	LB I	731530													1	0
2-E-25-2	5155IV	*	813497	No data													
2-E-25-3	5155III	*	736372	No data													
2-E-25-4	5155III	LB II	724376	175	170	175	175	30	24	30	24	-24	-12			7	5
2-E-25-5	5155III	LB II	704372	168	130	170	175	54	40	54	24	+68	-58	+140	-24	9	3
2-E-25-6	5155II	LB III	933286	135	130	165	160	48	90	48	90	-72	-56	-16	0	10	5
2-E-27-1	5154I	LB IV	923114	115	115	155	160	48	108	48	108	-48	-72	+72	+48	14	4.5
2-E-27-2	5154I	LB III	905133	140	155	170	170	36		36		-36		+24		9	4
2-E-27-3	5154IV	*	862174	140	130	145	155	36	36	36	36	0	-66	+72	0	9	3
2-E-27-4	5154IV	*	879172	135	160	166	175	132	70	132	70	-60	-36	+12	+48	17	10

Site No.	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
2-E-25-1	165	24			190	175	120	240			115	12	2
2-E-25-2													
2-E-25-3													
2-E-25-4													
2-E-25-5													
2-E-25-6													
2-E-27-1													
2-E-27-2													
2-E-27-3													
2-E-27-4													

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(3 of 3 sheets)

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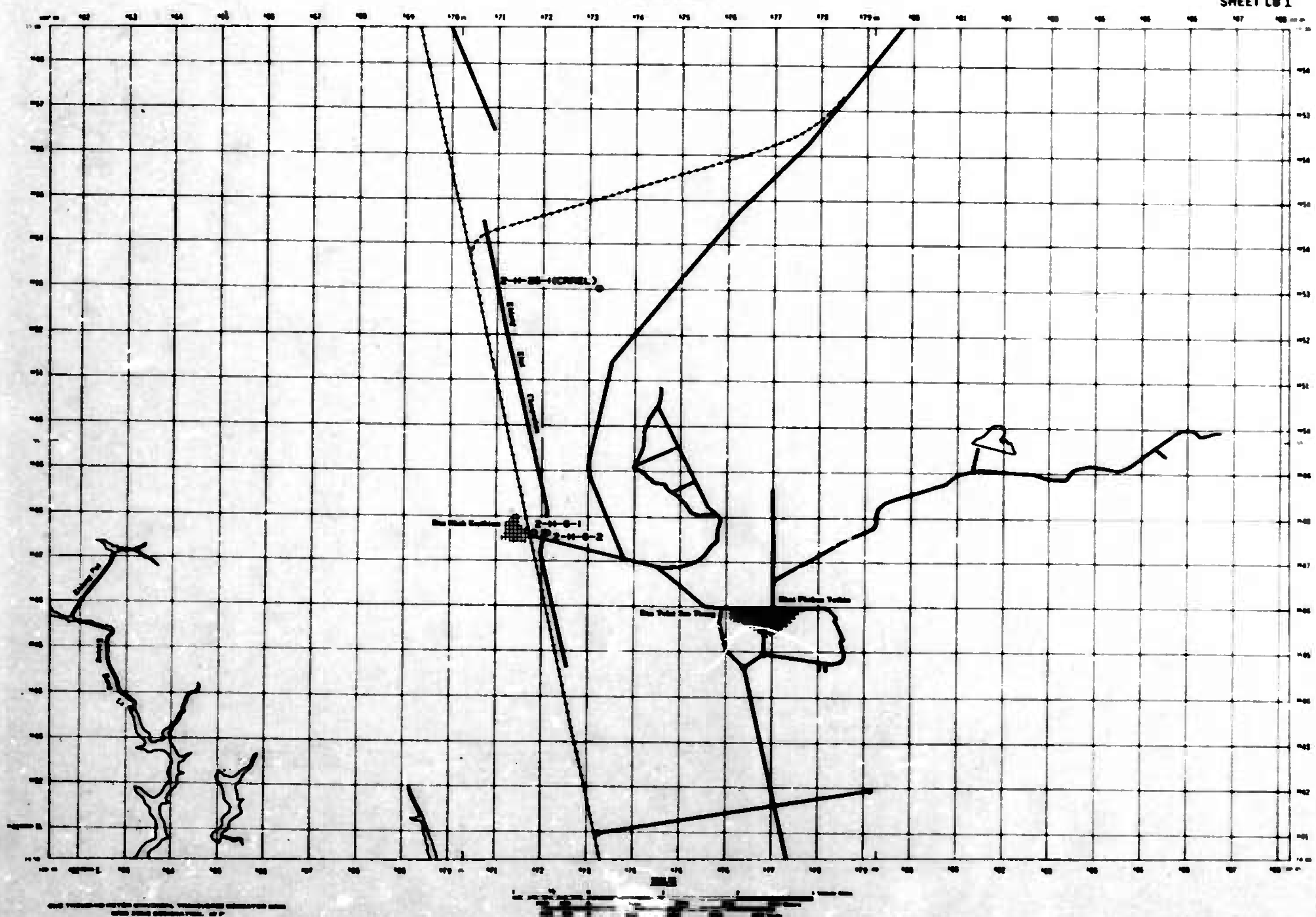
LOP BURI

SHEET LB I



HYDROLOGIC GEOMETRY SITES
LOP BURI STUDY AREA
SHEET LB I

FIG. A6

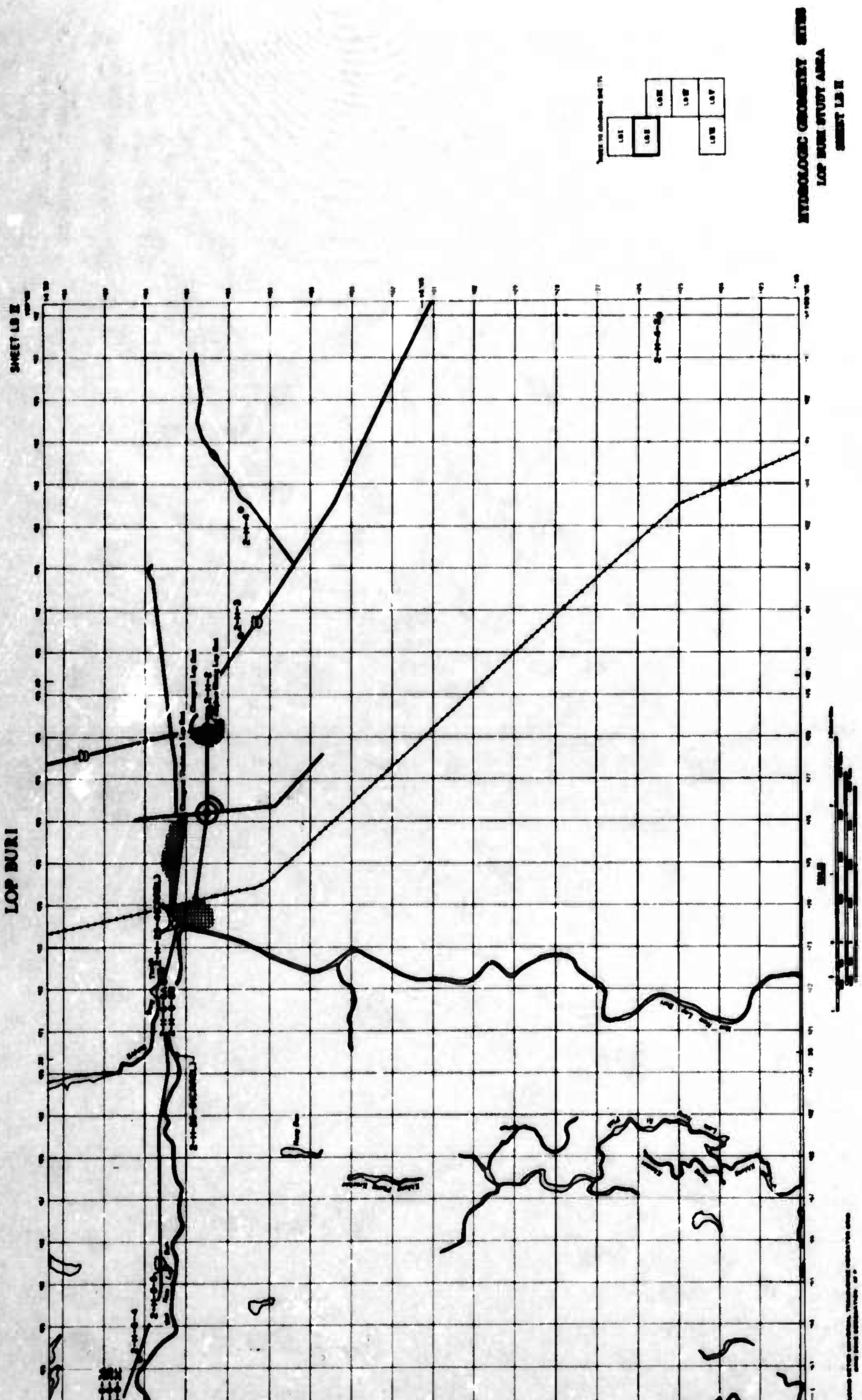

LOP BURI
SHEET LB II
HYDROLOGIC GEOMETRY SITES
LOP BURI STUDY AREA
SHEET LB II

FIG. A7

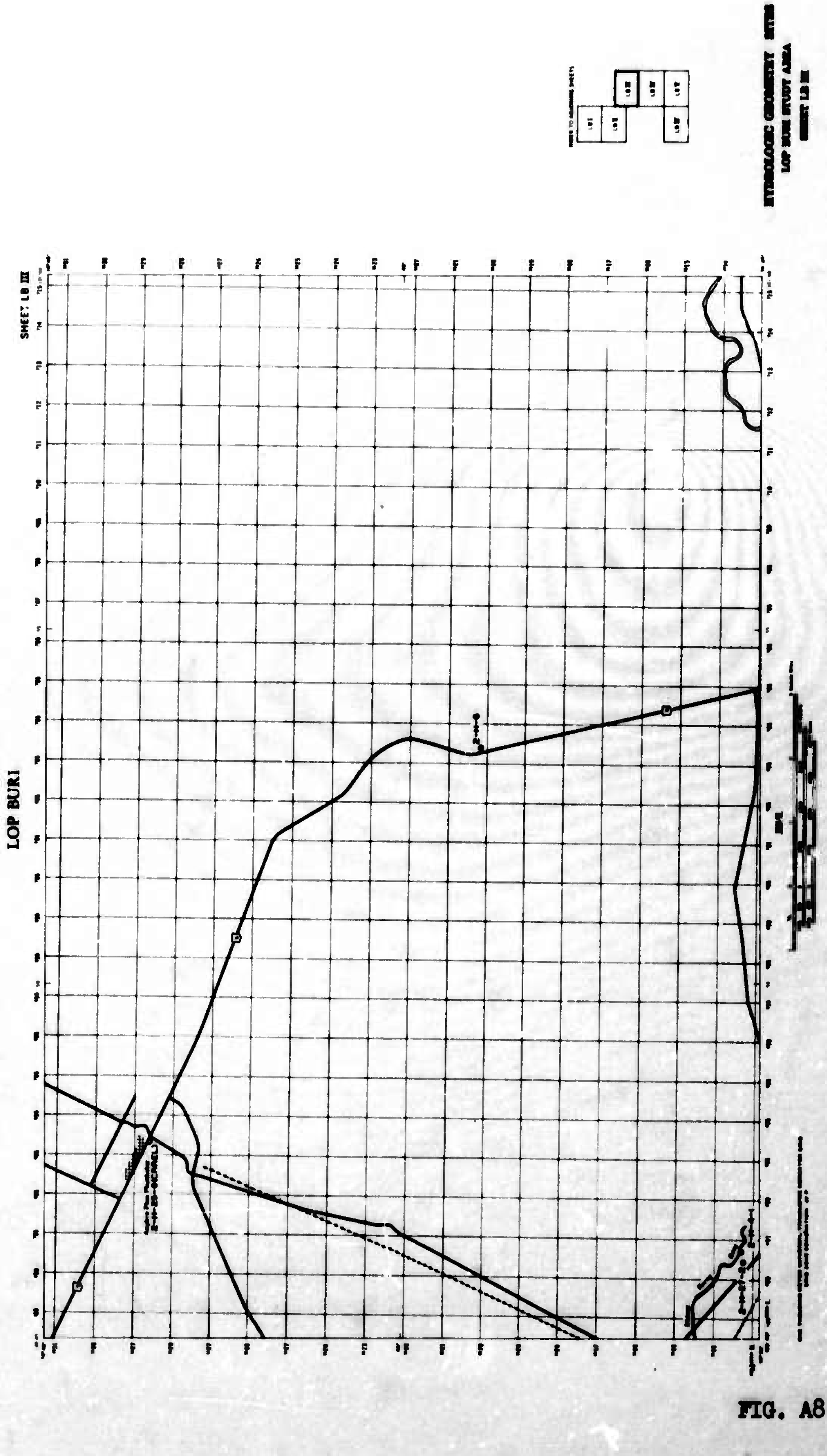

LOP BURI
SHEET LB III
HYDROLOGIC GEOMETRY SITES
LOP BURI STUDY AREA
SHEET LB III

FIG. A8

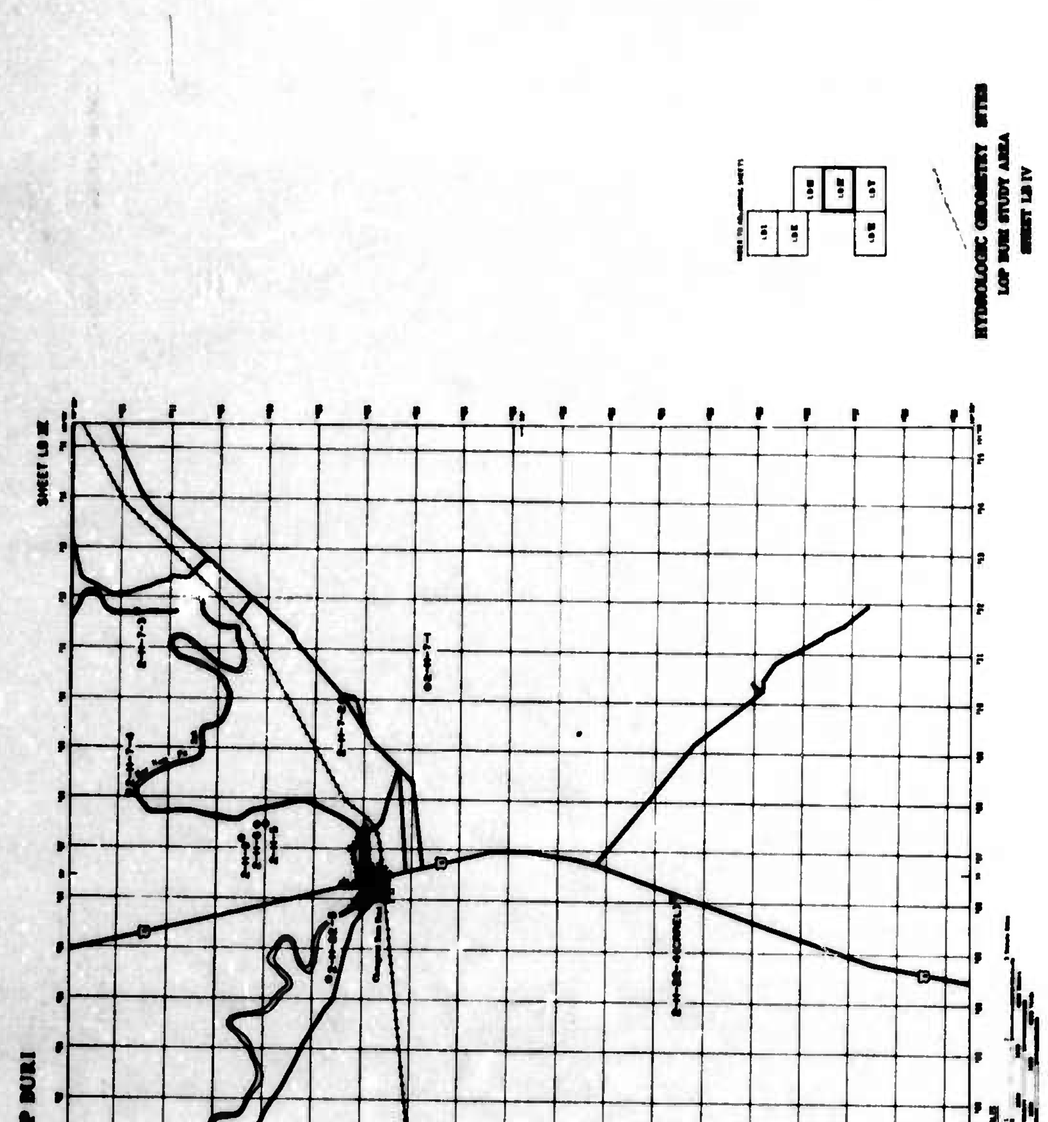

LOP BURI
SHEET LB III
HYDROLOGIC GEOMETRY SITES
LOP BURI STUDY AREA
SHEET LB IV

FIG. A9

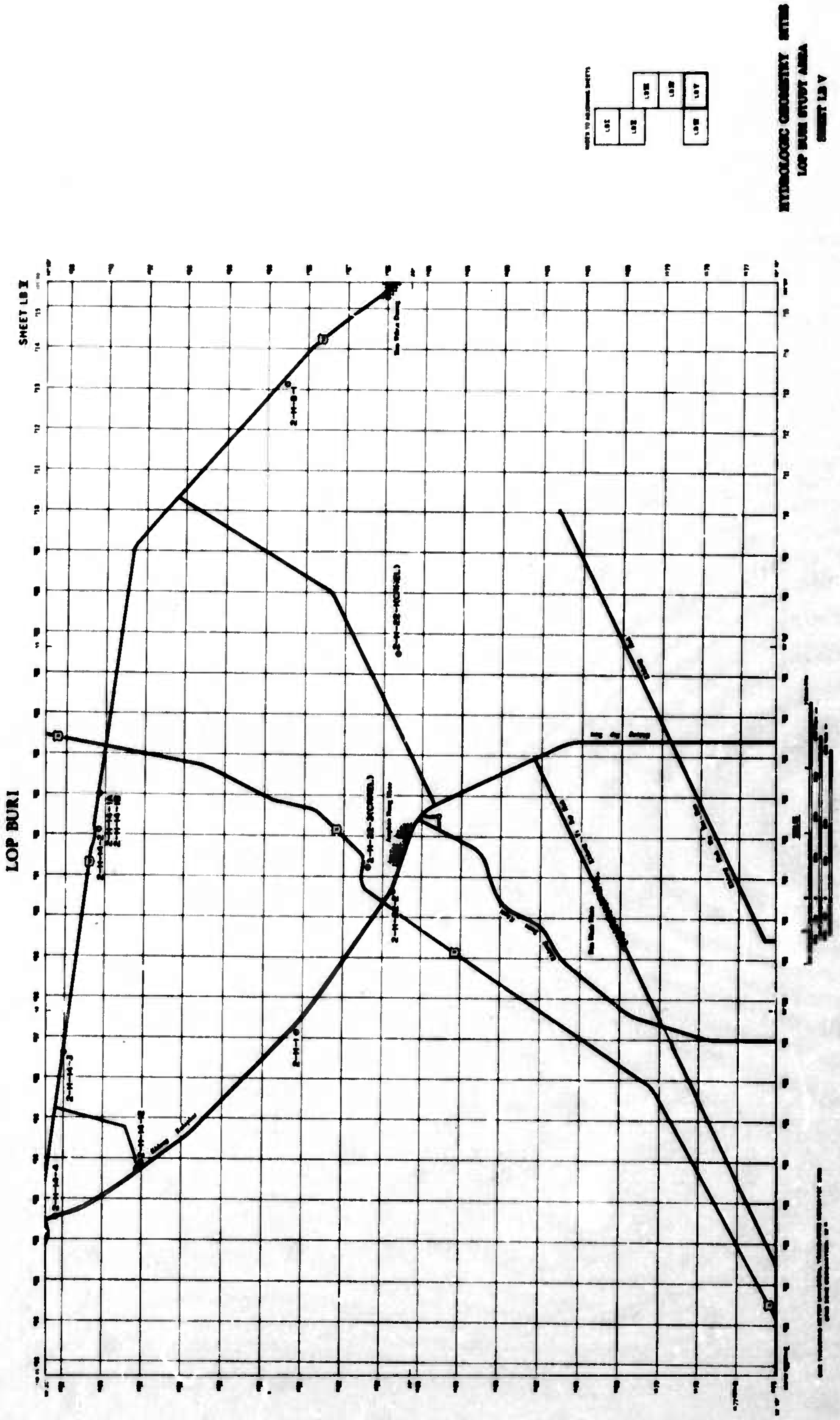

LOP BURI
SHEET LB I
HYDROLOGIC GEOMETRY SITES
LOP BURI STUDY AREA
SHEET LB V

FIG. A10

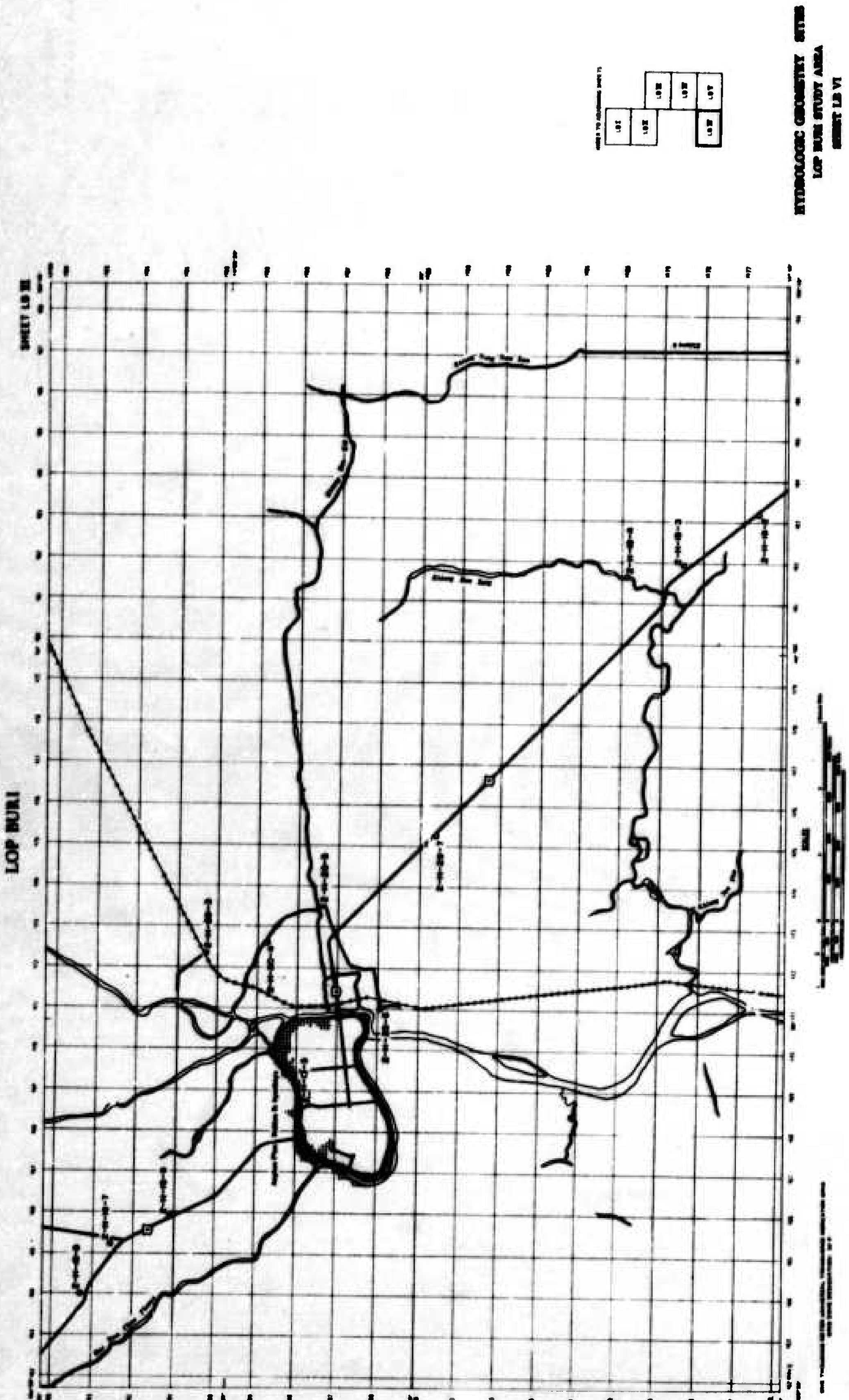

LOP BURI
SHEET LB III
HYDROLOGIC GEOMETRY SITES
LOP BURI STUDY AREA
SHEET LB VI

FIG. A11

CHIANG MAI

Table A3

Summary of Hydrologic and Surface Geometry Field Data

Chiang Mai

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	Contact Approach Angle, deg, Max Wtr W	Contact Approach Angle, deg, Max Wtr E	Contact Approach Angle, deg, Min Wtr W	Contact Approach Angle, deg, Min Wtr E	Step** Height, in., Max Wtr W	Step** Height, in., Max Wtr E	Step** Height, in., Min Wtr W	Step** Height, in., Min Wtr E	Position of Step Base,† in., Max Wtr W	Position of Step Base,† in., Max Wtr E	Position of Step Base,† in., Min Wtr W	Position of Step Base,† in., Min Wtr E	Water Depth ft Max Wtr	Water Depth ft Min Wtr	1†† App Angle	1†† Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
3-H-1	4867III	CM II	139794	140	168			48	42			-54	-42			7	2					225	140	140	210					7
3-H-2	4767II	CM I	977746													2.5	1	125	18			250	110	130	250			160	22	3.5
3-H-3	4766I	CM IV	897602													2.5	0	135	18	165	18	235	120	138	215			132	54	3
3-H-4	4767II	CM I	971737	140	110			24	22			-24	-32			4.0	1	160	20			222	130	100	227					-
3-H-5	4767II	CM IV	935683													2	0	125	12			210	130	110	200			160	4	2.5
3-H-6	4767II	CM IV	965728													2	0	130	36			230	130	130	200			140	10	2.5
3-H-7	4767II	CM IV	930674	110	108			30	12			-22	-36			3	0	125	24			238	108	110	230			140	36	3.5
3-H-8	4767II	CM IV	954711	130	95			18	18			-18	-30			4.5	1	145	10			220	130	90	250			130	12	5.5
3-H-9	4767I	‡	956916	100	130			48	14			-54	-18			4.5	1.5					230	100	140	220					6
3-H-10	4767II	CM IV	946699													2.5	0					190	140	140	190	165	24			4
3-H-11	4767II	CM IV	914645	158	140				60				-48			4	0					212	140	158	210					5
3-H-12	4766I	CM IV	843575													2.5	0	175	12			220	100	100	240			110	30	3.5
3-H-13	4766I	CM IV	829569													2.0	0	140	08			240	110	90	270			140	18	3
3-H-14	4766I	‡	847485													2.0	0.5	145				270	90	150	200					4
3-H-15	4766I	‡	859488													2.5	0.5	160	66	155	40	220	140	110	245			135	12	3
3-H-16	4766I	CM IV	867585	148	160											7.0	2.5					210	110	135	220					8
3-H-17	4766I	CM IV	814562													2.0	0.0	120	32			200	130	110	240			164	30	2
3-H-18	4766I	CM IV	893573													2.5	0.5					250	90	155	200					3
3-H-19	4766I	‡	833495													1.5	0.0	110	15			210	90	110	270					3
3-H-20	4867III	CM II	045762													2.7	0.5					200	150	90	240			137	48	3
3-H-21	4867III	CM II	052763	110	150	165	165	54		90		-54		-16		10.0	5.1													
3-H-22	4867III	CM II	066758	165	160				52		21		-6		+18	8.0	1.0	150	18			240	90	145	220			150	12	12
3-H-23	4867III	CM II	060754													2.5	0.5					200	110	125	200					3
3-H-24	4867III	CM III	137709	158	173											5.5	0.5	115	14			210	155	175	200			170	18	6.5
3-H-25	4867III	CM II	104736													2	0	160	18			240	130	100	220			140	11	3
3-H-26	4867III	CM II	164751	100	125											4	1	150	24			220	125	100	210	150	23	130	20	4
3-H-27	4867III	CM II	028793	140	130	165	160	44	45	78	45	-54	-51	-33	+3	14	10													
3-H-28A	4867III	CM II	055814													2	0	135	27			270	140	140	195					2
3-H-28B	4867III	CM II	055814	155	170											3	0					195	160	150	220			158	45	3
3-H-29	4867III	CM II	058818	155	145				21				0			6	2	158	40			220	150	155	220			157	54	6
3-H-30	4867III	CM II	062820	140	130											4	1	160	35			210	140	140	205			158	54	5
3-H-31	4867IV	CM II	077828	155	175											5	1	145	57			225	152	155	230			150	30	8
3-H-32	4867IV	CM II	079831	98	90											3	0	160	9			220	100	90	200			145	10	4
3-H-33	4867IV	CM II	083834	157	160			17	68			0	-48			5	1	145	27			200	140	140	220			130	30	6
3-H-34	4867IV	CM II	089831	145	110											3	0	130	8			215	110	145	200	140	12	140	12	4
3-H-35	4867IV	CM II	140861	125	105			25				-25				4	0	150	20			220	110	140	230			150	20	5
3-H-36A	4867IV	CM II	156868													2	0	155	15			260	145	140	225			170	17	3
3-H-36B	4867IV	CM II	156868	145	140											4	1	175	5			220	145	145	190			165	46	5
3-H-37	4867IV	CM II	048828	105	140											4	2	160	48			193	140	115	200			135	36	7
3-H-38	4867III	CM II	089821													2	0					190	135	115	230			125	30	3

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.

** A step is a slope change that is >35 deg.

† Position of step base is referenced to water level.

†† For position of numerically designated approach angle and step height see fig. 6.

‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(1 of 3 sheets)

Table A3 (Continued)

				Hydrologic Geometry at East and West Banks												Water Depth ft		Surface Geometry												
				Contact Approach Angle, deg				Step Height, in.				Position of Step Base, in.						Critical Approach Angle, deg and Step Height, in.												
				Max Wtr		Min Wtr		Max Wtr		Min Wtr		Max Wtr		Min Wtr				1		2		3	4	5	6	7		8		
Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	W	E	W	E	W	E	W	E	W	E	W	E	Max Wtr	Min Wtr	App Angle	Step Ht	App Angle	Step Ht	App Angle	App Angle	App Angle	App Angle	App Angle	Step Ht	App Angle	Step Ht	CD ft
3-H-39	4867IV	CM II	052851	150	90											3	0	135	20			215	90	155	185			155	20	4
3-H-40	4867IV	CM II	049869													2	0	125	28			230	90	90	270			120	30	3
3-H-41	4867IV	CM II	011894	125	125			60	48			-48	-48			4	1					200	125	125	210					5
3-H-42	4867IV	CM II	021899	130	130			34	30			-34	-60			5	1.5	148	36			210	130	125	240	155	42	154	66	7
3-H-43	4867IV	CM II	025864													2.5	0	125	15			250	90	120	230			120	15	3
3-H-44	4767I	*	991935	155	145			24	46			-36	0			6	1					245	140	140	250	150	16	150	12	10
3-H-45A	4867III	CM III	045691													2.5	1	168	24			270	90	90	270					4
3-H-45B	4867III	CM III	045691	115	90											3	1					270	90	110	220			145	8	3.5
3-H-46	4867III	CM III	048694	160	175				24				-30			4.5	2	150	24			270	90	120	200			130	36	6
3-H-47	4867III	CM III	042687													1.5	0					210	160	150	210					2.5
3-H-48	4867III	CM III	073703	90	120			24	18							3.5	1.5	165	32			240	110	110	260					4.5
3-H-49	4867III	CM III	057699	150	90			20	26			-36	-28			3	1	130	54			210	130	110	240			110	18	3.5
3-H-50	4866IV	CM III	046606													2.5	0					230	110	135	230			130		3
3-H-51	4866IV	CM III	016624	165	165			18	25			-35	-30			5	2					205	155	110	200					6
3-H-52	4766I	*	951496	115	140	125	155	28	27	54	66	-24	-24	+6	-6	15	8													
3-H-53	4866IV	*	041513	155	130											8	2					200	155	132	200					12
3-H-54	4866IV	*	070523	150	158											3	0					210	150	158	215					4
3-H-55	4767I	*	947942													2	0	140				200	130	90	270			90	15	2
3-H-56	4767I	CM I	953891	130	150				25				0			4	1					190	130	150	230					5
3-H-57	4767I	*	915962	120	130				26				-26			5	1					220	120	125	230					5.5
3-H-58	4766I	*	942475	165	145											4	1					215	165	145	205					4.5
3-H-59	4867III	CM III	016670	125	90											4	1	130	22			225	90	120	235			120	32	4
3-H-60	4767II	CM IV	998658	160	132											5	2					235	130	165	220			150	10	6.5
3-H-61	4766I	CM IV	794563	150	165											6	2					200	160	130	240					4
3-H-62	4766I	CM IV	791551	162	160	165	155	72	43	72	43	-42	-41	0	0	7	3.5													
3-H-63	4766I	CM IV	850571	160	173	130	155									9	4.5													
3-H-64	476 I	CM IV	817563													2.5	0	130	15			245	115	120	220			150	36	3.5
3-H-65A	4766I	CM IV	964564	100	110											5	1	135	26		**	230	105	100	270					6
3-H-65B	4766I	CM IV	964564	90	90											5	1	150	13		**	215	90	90	270			165	40	5.5
3-H-66	4766I	CM IV	949582	155	120											4	1	140	16		**	215	155	120	195					5
3-H-67	4766I	CM IV	924592	90	90											4	1	140	10			235	100	110	200			140	8	5.5
3-H-68	4766I	CM IV	908594	90	110											3.5	1					215	130	90	260					4.5
3-H-69	4867III	CM II	134804	90	90											4	1	160	25	**	40	270	95	100	270			155	29	5
3-H-70	4867IV	CM II	138826	90	90											5	1					265	90	90	270			145	29	6
3-H-71	4766III	*	705399													2	0					230	130	160	195					3.5
3-H-72	4766III	*	678389	100	135											4	0					195	135	100	250					7
3-H-73	4766III	*	660269													2	0					210	145	160	190					2
3-H-74	4765IV	*	632239	160	135											4	0					220	135	160	190					6
3-H-75	4765IV	*	625225	172	162											5	1					198	162	155	200					5
3-H-76	4765IV	*	603184	150	120				12				-12			6	1					215	140	160	215					7
3-H-77	4766III	*	665324	110	170	155	170		22	55	22		-20	0	+30	9	4													
3-H-78	4867III	CM III	118684													2	0	140	27			220	150	155	230			145	27	2
3-H-79	4867III	*	112662													2	0					215	135	105	240	145	10	155	9	3
3-H-80	4867III	CM III	162648													2	0	135	12			205	155	160	195			140	14	4
3-H-81	4866IV	CM III	126618	165	170			12				+7				3	0					215	165	170	190					5
3-H-82	4866IV	CM III	115608													2	0	145	10			225	110	130	210					4
3-H-83	4766I	*	895475	140	165			48				-28				5.5	1					230	130	160	210					7
3-H-84A	4866IV	CM III	027582													2	0.5	150	30			220	120	130	220			170	14	3.5
3-H-84B	4866IV	CM III	027582													2	0	150	12			250	120	90	270			160	12	3
3-H-85A	4766I	*	924471	90	90			60	60			-42	-36			3.5	0.5					230	90	90	250			110	36	5

(Continued)

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A3 (Concluded)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Step Height, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Position of Step Base, in.: Max Wtr W	Max Wtr E	Min Wtr W	Min Wtr E	Water Depth ft: Max Wtr	Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
3-H-85B	4766I	*	924471	140	140			36	60			-42	-42			4	0.5	90	30			210	140	150	210					5
3-H-86	4766I	*	911466													2.5	1.0					270	100	100	240					4
3-H-87	4767II	CM I	9[illegible]801	150	127				126				-60			5.5	0.0					195	145	130	230					8
3-H-88	4767I	CM I	973[illegible]													2	0					240	120	155	210					2.5
3-H-89	4767I	CM I	[illegible]05913													2.5	1					210	150	110	250					5.5
3-H-90	4767I	*	945004	163	145				108				-76			7.5	1.5			167	96	205	163	145	220	160	24	150	156	10
3-H-91	4767II	CM IV	976655	100	120											3	0	160	26			220	120	110	270			140	24	3.5
3-H-92	4767II	CM IV	978654	110	125			14	96			-70	-48			6	1.5	152	48			250	120	110	200	140	28	155	12	8
3-H-93	4767II	CM IV	961660													2.5	0	150	42			210	125	120	220					3
3-H-94	4767II	CM IV	904670	160	130											3	0	150	18			220	130	90	250			150	16	4
3-H-95	4767II	CM IV	912671													2.5	0.5					230	130	120	220					3.5
3-H-96	4766I	*	894499	120	110			36	36			-36	-36			4	1	150	30			260	110	90	260			130	24	7
3-H-97	4766I	*	901496	[illegible]	90											5	1	145	36			255	90	90	260			150	48	6
3-H-98	4766I	*	876520	90	90											7	2.5	165	36			270	90	90	230			160	26	9.5
3-H-99	4767II	CM IV	947720	150	150			30	24			-20	-28			4	0					210	110	140	230					5
3-H-100	4867III	CM III	187718	90	100											4.5	1.0					240	90	100	250					5.5
3-H-101	4867III	CM III	254728	125	132					55				+18		7.5	2.5					225	132	140	230					7
3-H-102	4867III	CM III	223719	90	105											3.5	0.0					220	105	90	260					5.5
3-H-103	4867III	CM II	172767													2.5	0.0			150	24	210	150	140	220					4
3-H-104	4867III	CM II	184784													2.5	0.0					200	150	160	195					3.5
3-H-105A	4766I	*	819524	140	140	140	140	36	24	36	24	-6	-6	+30	+30	3.5	0.5	140	42			265	140	140	220					5.5
3-H-105B	4766I	*	81952[illegible]													2.0	0.0					240	140	110	220					3
3-H-106	4766I	*	821519													2.5	0.5	150	27			250	90	110	220					3.5
3-H-107	4766I	CM IV	841603													2.0	0.0					220	115	130	220					2
3-H-108	4766I	CM IV	843606	165	160	165	160	36	30	36	30	-32	-24	+16	+24	4.0	0.0			170	48	220	100	110	230					9
3-H-109	4867IV	CM II	111846													2.5	0.0			165	48	210	130	110	260					3.5
3-H-110	4867IV	CM II	170857													2.5	0.7					200	160	160	200					3
3-H-111	4867IV	CM II	177853	130	145											5.0	0.5					210	145	130	210					7
3-H-112	4867III	CM II	211819	120	120						50					6.0	1.5					240	130	120	240					7
3-H-113	4866IV	CM III	063612	160	170	160	170	16		16		0		+34		5.5	3.0													
3-H-114	4866IV	*	076533	160	177				30		30		+18		+84	6.5	1.5					190	160	135	210					10
3-H-115	4866IV	CM III	105584													1.5	0.0	165	28			210	130	125	210					2
3-H-116	4866IV	CM III	093562													1.5	0.0	160	06			200	140	110	250			130	12	2
3-H-117	4866IV	CM III	088549	110	100											3.0	0.5	160	15			240	112	110	230			110	24	3
3-H-118	4767II	CM I	876737													2.5	0.0					195	165	130	220	160	120			4
3-H-119	4767II	CM IV	897714	140	145			36	14			-36	0			3.0	0.5					210	155	150	220					3.5
3-H-120	4767I	*	980999	140	110			32	48			-28	-36			4.0	1.0					210	140	110	240					8
3-H-121	4767I	*	981997	90	90			20	20			-48	-48			5.0	1.5	150	24	160	12	255	90	90	270	150	30	160	30	6
3-H-122	4867IV	CM II	046856													2.5	0					200	147	130	200					3
3-H-123	4867IV	CM II	048842													2.0	0					210	120	140	200	140	10	145	10	2.5
3-H-124	4867III	CM II	020795													2.5	1	130	9			220	140	130	220					3
3-H-125	4767I	CM I	965742													2.5	0					270	90	165	270			110	6	3

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

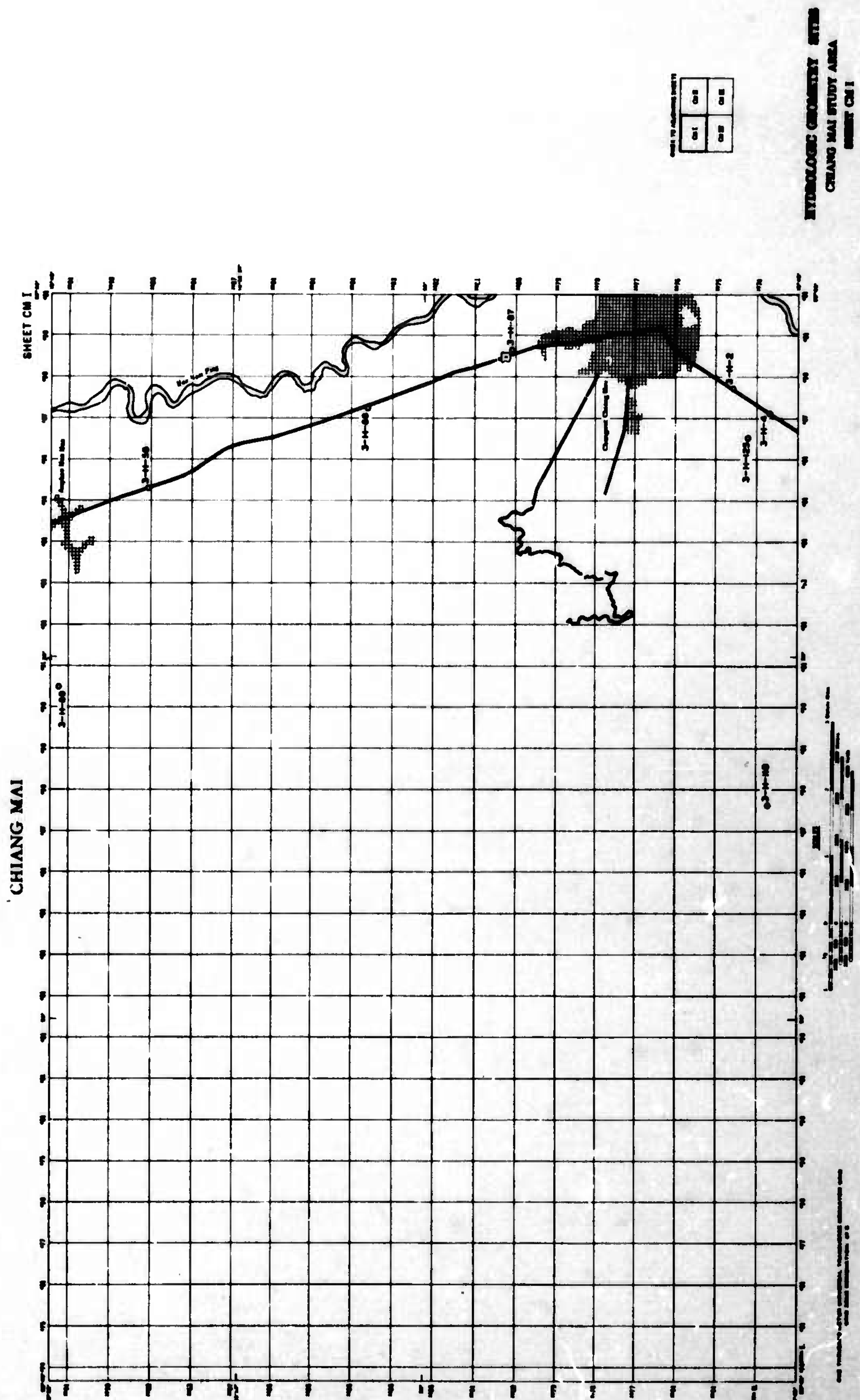

CHIANG MAI
SHEET CM 1
HYDROLOGIC GEOMETRY SITES
CHIANG MAI STUDY AREA
SHEET CM 1

FIG. A12

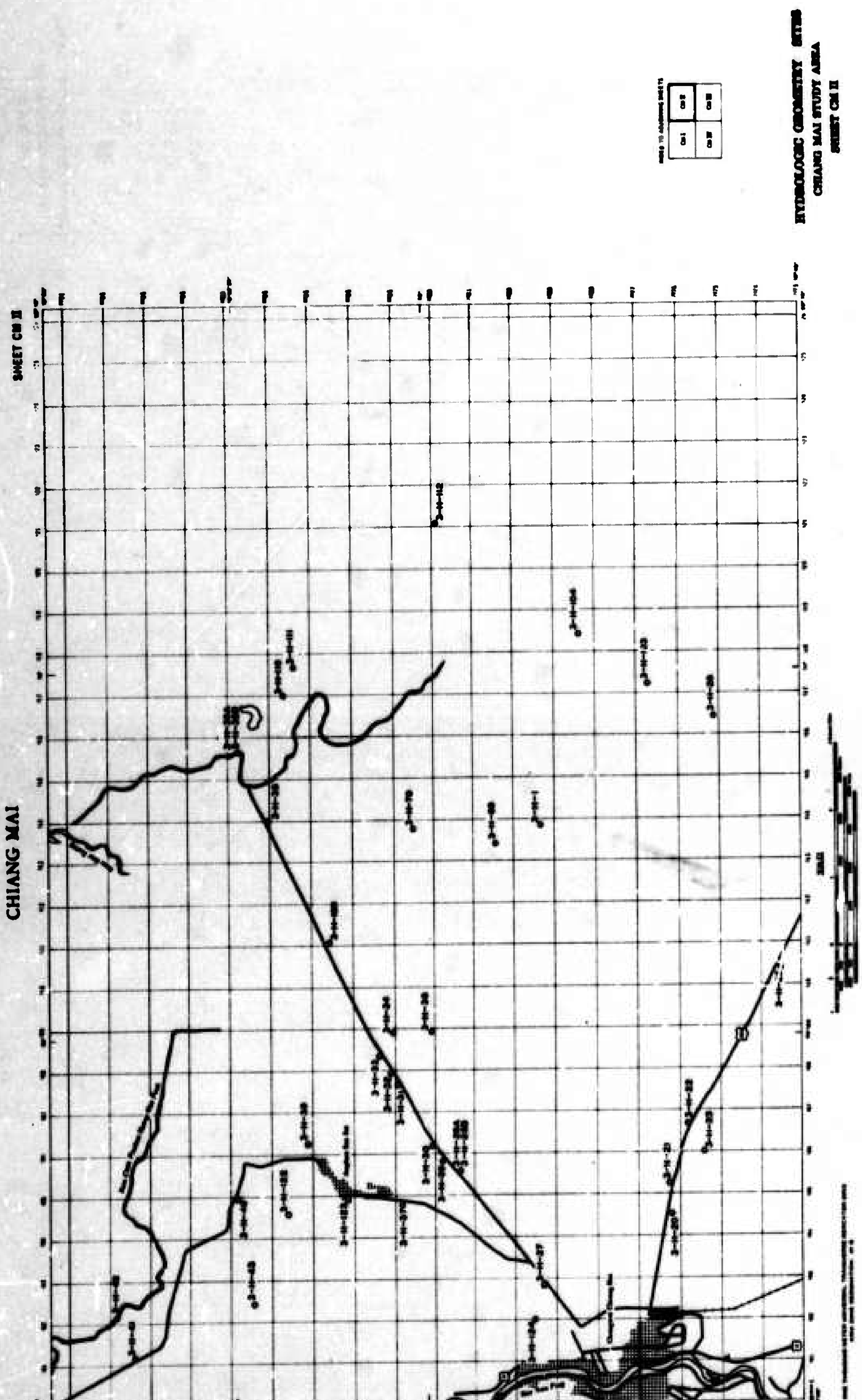
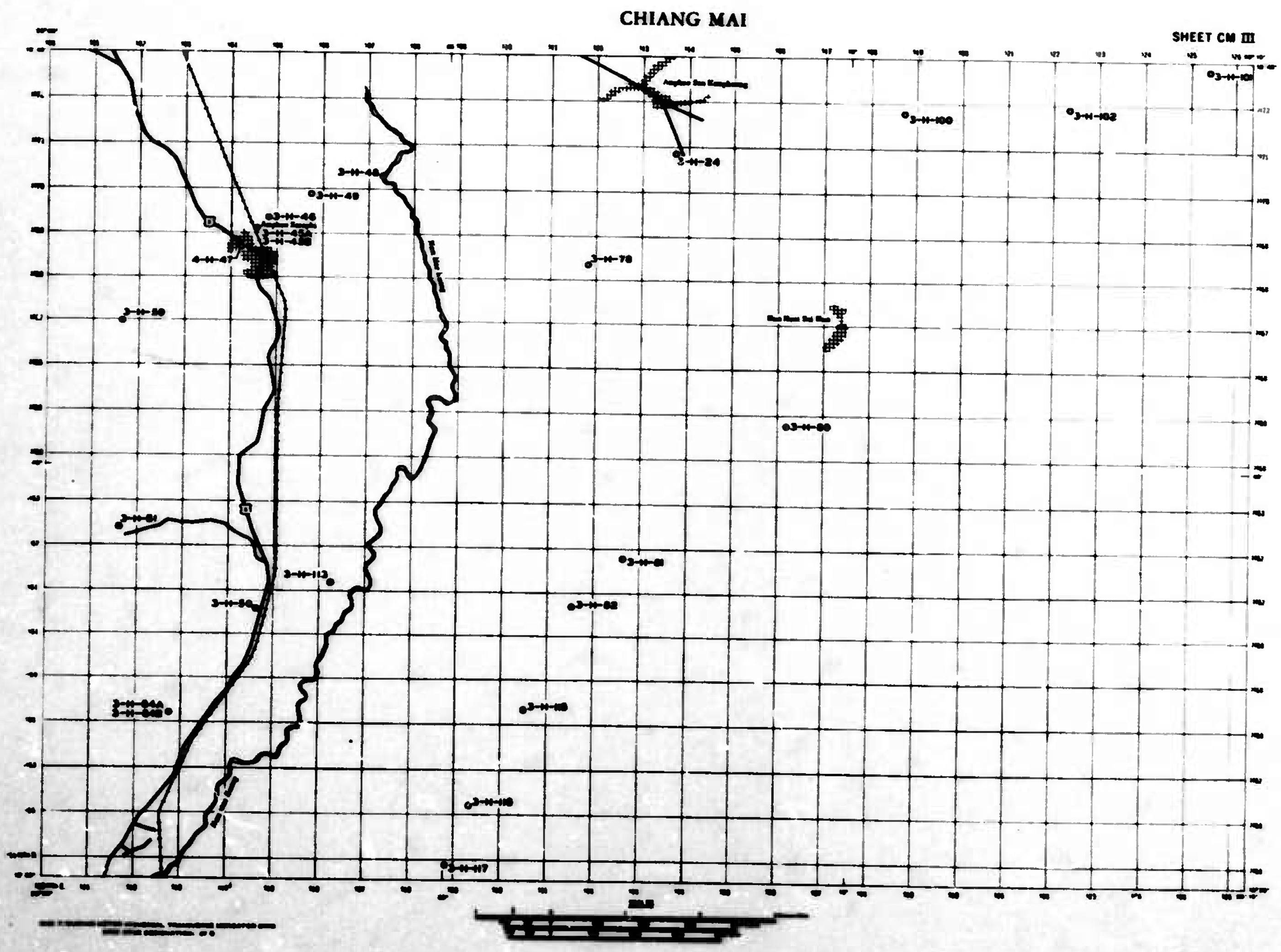

CHIANG MAI
SHEET CM II
HYDROLOGIC GEOMETRY SITES
CHIANG MAI STUDY AREA
SHEET CM II

FIG. A13



HYDROLOGIC GEOMETRY SITES
CHIANG MAI STUDY AREA
SHEET CM III

FIG. A14

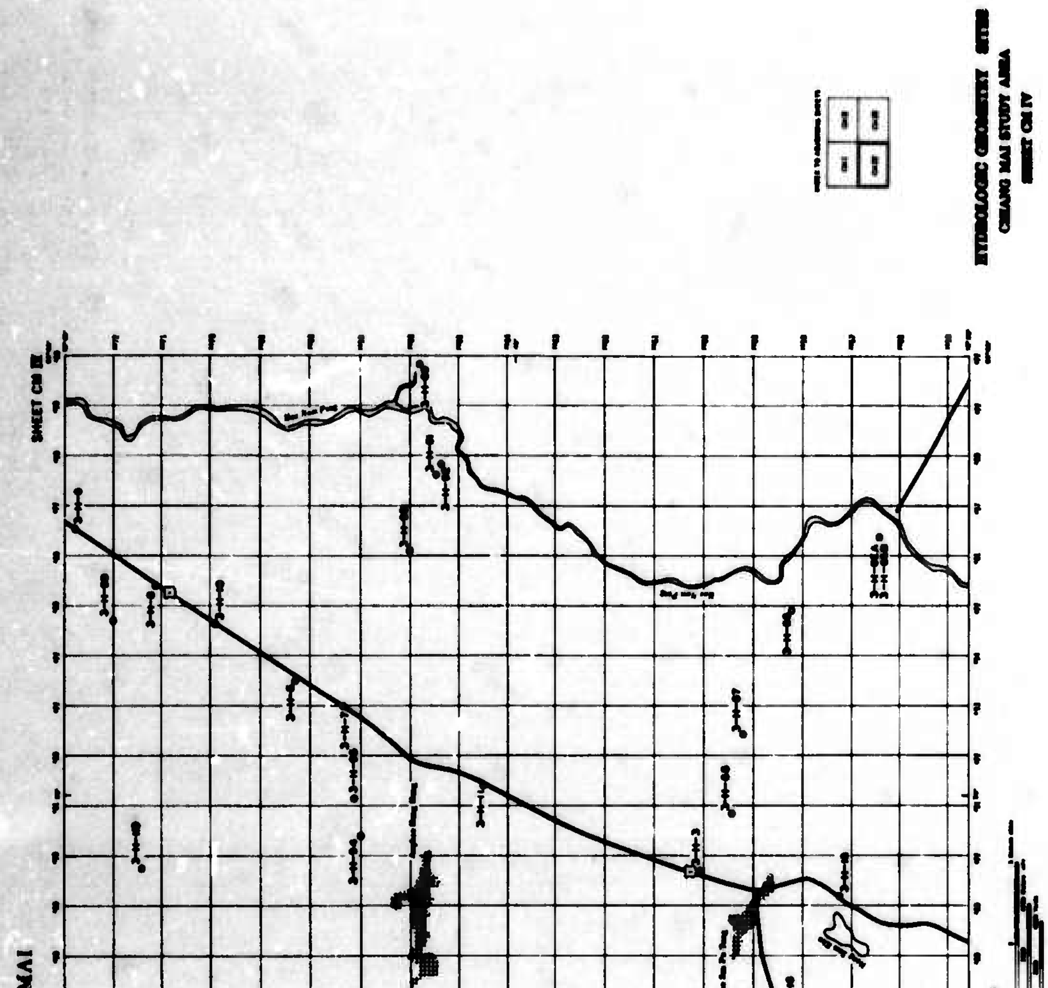

CHIANG MAI
SHEET CM III
HYDROLOGIC GEOMETRY SITES
CHIANG MAI STUDY AREA
SHEET CM IV

FIG. A15

PRAN BURI

Table A4

Summary of Hydrologic and Surface Geometry Field Data

Pran Buri

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg, Max Wtr W	Contact Approach Angle, Max Wtr E	Contact Approach Angle, Min Wtr W	Contact Approach Angle, Min Wtr E	Step** Height, in., Max Wtr W	Step Height, Max Wtr E	Step Height, Min Wtr W	Step Height, Min Wtr E	Position of Step Base,† in., Max Wtr W	Position of Step Base, Max Wtr E	Position of Step Base, Min Wtr W	Position of Step Base, Min Wtr E	Water Depth ft, Max Wtr	Water Depth ft, Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1†† App Angle	1†† Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
4-H-1	4948II	PB I	029736	135	120	150	165			36	84			0	0	13	9													17
4-H-2		‡	Not Used																											
4-H-3	4948II	PB I	868778	125	120	140	140	150		150	150	+198		+276	+276	10	3													39
4-H-4	4948II	PB I	877782	160	140	160	150	48		48	54	-48		+48	+96	11	3													31
4-H-5	4948II	PB I	907766	97	170	165	135	372	96	372	126	-138	0	0	-72	22	10													41
4-H-6	4948II	PB I	903733	135	175			36				+72				6	1					210	154	130	230					18
4-H-7	4948II	PB I	923730	170	90	160	160		108		108		-36		+50	16.5	9.5													16.5
4-H-8	4948II	PB II	939714	160	170							-18	24			80	8					220	130	120	250					8
4-H-9	4948II	PB IV	953710	160	160	160	165		36		36		-42		+6	9.5	5.5													10
4-H-10	4948II	PB II	959718	145	160	165	155	168	60	168	60	-130	0	+30	+156	17	4													23
4-H-11	4948II	PB II	983702	130	145	155	145									13	8													18
4-H-12	4948II	PB II	988701	175	150	160	165	120	180	120	180	+49	-24	+100	+42	10	5													23
4-H-13	4948II	PB II	017682	125	175	155	155	88		88		-88		-36		13	8													13.5
4-H-14	4948II	PB II	022673	160	165	160	155	12		12		-48		+24		11	6													11
4-H-15	4948II	PB II	058648	160	170	160	155	48	42	48	42	-48	+6	+24	+78	23	17													23.5
4-H-16	4948II	PB II	053711	160	175	146	170									13	[illegible]													13
4-H-17	4947I	PB III	845510													2.5	0					220	130	140	210					7
4-H-18	4947I	PB III	896511													2.5	0					230	135	125	190					
4-H-19	4947I	PB III	954502	130	130											5	0					210	130	130	200					7
4-H-20	4947I	PB III	892476	160	165				18							2	0					200	160	140	210					5
4-H-21	4947I	PB III	872495	145	150											4	0					210	145	150	210					5
4-H-22	4947II	PB III	928441	130	120			36	72			-60	-54			8	2.5					230	130	120	240					8.5
4-H-23	4947I	PB II	936547													2.5	0					210	150	140	220					2.5
4-H-24	4947I	PB III	880509	90	90											5	0					240	90	90						8
4-H-25	4947I	PB II	904575	175	160				18				+30			4.5	0					205	155	125	270					5.5
4-H-26	4947I	PB II	894568	130	140		54									3.5	0					210	120	140	195					4.5
4-H-27	4947I	PB II	932620	155	150											3.5	0					200	155	120	220					5
4-H-28	4948II	PB II	969639													2.5	0					210	145	155	210					4.5
4-H-29	4948II	PB II	929642	150	155											3	0					190	150	155	200					3
4-H-30	4948II	PB II	919694	140	140											3	0					185	140	140	205					3.5
4-H-31	4948II	PB II	898687													2	0					200	150	140	200					3
4-H-32	4948I	PB I	898878	130	165											3	0					195	130	165	185					6
4-H-33	4948I	PB II	899714	165	155											8	0					200	155	150	210					10
4-H-34	4948II	PB II	020719	90	145	155	170	42	12	12	12	-24	-24	-18	+12	7.5	3													8
4-H-35	4948II	PB I	056813	155	160				36				-30			3.5	0					220	155	120	240					4
4-H-36	4947II	PB III	923443	130	140											3	0					225	135	165	190					3
4-H-37	4947II	PB II	997677	150	155			24				-30				6	0					215	145	155	210					6
4-H-38A	4947II	PB II	991695	155	147			42				-42				6	0					220	150	150	210	155	96	150	48	10
4-H-38B	4947II	PB II	991695	155	140			66	42			+24	-84			7	0	155	96	150	48	210	120	120	200					9
4-H-39	4947II	PB I	007730													2.5	0					210	145	135	225					3

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.

** A step is a slope change that is >35 deg.

† Position of step base is referenced to water level.

†† For position of numerically designated approach angle and step height see fig. 6.

‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A4 (Continued)

				Hydrologic Geometry at East and West Banks												Water Depth ft		Surface Geometry												
			Military	Contact Approach Angle, deg				Step Height, in.				Position of Step Base, in.						Critical Approach Angle, deg and Step Height, in.												
	AMS	MERS	Grid	Max Wtr		Min Wtr		Max Wtr		Min Wtr		Max Wtr		Min Wtr		Max	Min	1		2		3	4	5	6	7		8		
	Map	Quad	Coordi-															App	Step	App	Step	App	App	App	App	App	Step	App	Step	CD
Site No.	Sheet	No.	nates	W	E	W	E	W	E	W	E	W	E	W	E	Wtr	Wtr	Angle	Ht	Angle	Ht	Angle	Angle	Angle	Angle	Angle	Ht	Angle	Ht	ft
4-H-40	4947II	PB II	896696													2	0					190	130	165	185					3
4-H-41	4947II	PB II	895702													2	0					230	130	100	260					3
4-H-42	4947II	PB I	846744	145	135											6	0					210	145	135	220					9
4-H-43	4947II	PB II	928701													2	0					240	130	120	200					4
4-H-44	4947II	PB II	970571	150	150											4.5	0					190	150	150	210					7
4-H-45	4947II	PB III	906514	160	155			48	60			+24	-24			3	0					210	150	150	210					6
4-H-46	4948II	PB II	923702																											
4-H-47	4947I	PB III	902520													2	0					230	125	155	200					6
4-H-48	4947I	PB III	879517	140	120											4	0					210	140	120	200					8
4-H-49	4947I	PB III	896517													2	0					210	120	110	230					4
4-H-50	4948I	PB I	974865	160	120			30								4	0					150	120	90	250					8
4-H-51	4948I	PB I	987853													2	0					230	130	140	210					3
4-H-52	4947I	PB III	885485													2	0					190	160	160	200					4
4-H-53	4947I	PB III	873477	165	145											5	0					240	120	145	205					5
4-H-54	4947I	PB III	905458													2	0					200	140	150	200					4
4-H-55	4947I	PB III	922466	140	110											3.5	0					240	110	140	220					5
4-H-56	4947I	PB II	910598													1	0					270	90	110	260					3
4-H-57	4947I	PB II	902609													1	0					190	170	170	190					2
4-H-58	4947I	PB II	897604													2	0					210	130	140	210					3
4-H-59	4947I	PB II	956610													2.5	0					210	130	120	220					3
4-H-60	4947I	PB III	931474	170	160			48				-48				5	0					185	140	160	185					8
4-H-61A	4947I	PB III	944512													2	0					205	140	100	240					3
4-H-61B	4947I	PB III	944512													2	0					210	130	140	205					2
4-H-62	4948II	PB I	010734	125	150			36	48			-36	-24			3.5	0.5					190	130	142	200					7
4-H-63	4948II	PB I	903744	120	115											2	0					225	120	110	220					9
4-H-64	4948II	PB I	899736													2.5	0					190	135	140	200					3
4-H-65	4948II	PB I	882741													2.5	0					185	160	150	185					3.5
4-H-66	4948II	PB I	887741													2	0					240	120	120	240			160	20	2.5
4-H-67	4947I	PB III	990508													2.5	1.6					185	175	175	185					3
4-H-68	4947I	PB III	002518	175	175											3	2.5					185	170	170	190					3.5
4-H-69	4947I	PB III	006523	90	90			54	54			-60	-60			5.5	4.5													6
4-H-70	4947I	PB III	006522	90	90			60	60			-72	-72			6.5	5.5													6.5
4-H-71	4947I	PB III	010528													1	1					230	130	165	195					1
4-H-72	4947I	PB III	984510													1.5	1					185	174	175	185					1.5
4-H-73	4947I	PB III	981516													1.5	1					185	175	175	185					1.5
4-H-74	4947I	PB III	9925[illegible]0													2.5	1.5					185	175	175	185					3
4-H-75	4947I	PB III	010525													2	1.5					200	160	160	200					2
4-H-76	4947I	PB III	968455													2.5	1.5					190	170	170	190					2
4-H-77	4947I	PB III	978470													2.5	1.5					190	170	170	190					2
4-H-78	4947I	PB III	977466													2	1					200	160	160	200					1.5
4-H-79	4947I	PB III	976465													2.5	1.5					190	170	170	190					2
4-H-80	4947I	PB III	983460													2	0.5					190	170	170	190					1.5
4-H-81	4947I	PB III	984456													2	1					185	175	175	185					1.5
4-H-82	4947II	PB III	964431													2	1					200	160	175	185					1.5
4-H-83	4947II	PB III	971428													2.5	1.5					190	170	165	195					2
4-H-84	4947I	PB III	972480													2.5	1					190	170	175	185					2.5
4-H-85	4947I	PB III	997487													2	1					185	175	190	170					1.5
4-H-86	4947I	PB III	007489													2.5	1					200	165	160	200					3
4-H-87	4947I	PB III	003486	Sinkhole, no data recorded														Sinkhole, no data recorded												
4-H-88	4947II	PB III	987443													1.5	0.5					190	170	175	185					2.5

(Continued)

Table A4 (Concluded)

Site No.	AMS Map Sheet	MGRS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Vtr: V	Max Vtr: E	Min Vtr: V	Min Vtr: E	Step Height, in.: Max Vtr: V	Max Vtr: E	Min Vtr: V	Min Vtr: E	Position of Step Base, in.: Max Vtr: V	Max Vtr: E	Min Vtr: V	Min Vtr: E	Water Depth ft: Max Vtr	Min Vtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1: App Angle	1: Step Ht	2: App Angle	2: Step Ht	3: App Angle	4: App Angle	5: App Angle	6: App Angle	7: App Angle	7: Step Ht	8: App Angle	8: Step Ht	CD ft
4-E-89	4947I	PB II	990553													2	1					185	175	175	185					1.5
4-E-90	4947I	PB III	961536													2.5	1.5					185	175	160	200					1.8
4-E-91	4947II	PB III	963440													1.5	1.0					190	170	175	185					1.5
4-E-92	4947II	PB III	966439													2.5	1.5					185	175	175	185					3
4-E-93	4947II	PB III	036423	175	170	175	175	42		42		-36		0		5.5	3													6.5
4-E-94	4947II	PB III	036422	170	165	165	165		24		24		0		+24	5.5	3.5													6.5
4-E-95	4949II	*	602401													2	0	165	34			220	130	130	220					7
4-E-96	4949II	*	604403													2	0					220	140	160	200					2
4-E-97		*	Not used																											
4-E-98		*	Not used																											
4-E-99	4948II	*	607370	165	160											5.7	1.0					190	165	165	190					4.2
4-E-100	4947II	*	593332	155	155	170	170	16	36	16	36	-36	0	+18	+60	7.5	3.5													
4-E-101	4947II	*	605341	170	175											4	1.5					195	165	155	205					6
4-E-102	4947II	*	594327													2	0					200	165	170	230					3
4-E-103		*	Not used																											

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

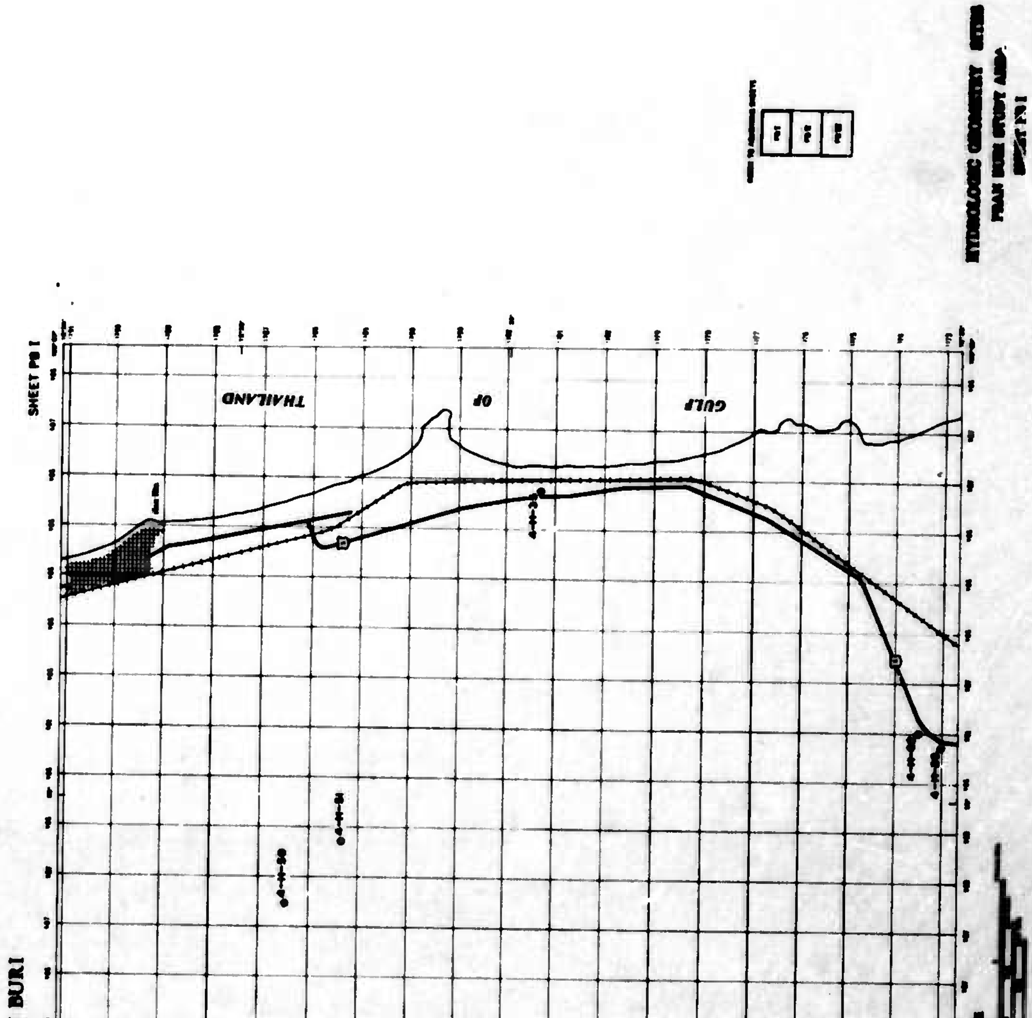


FIG. A16

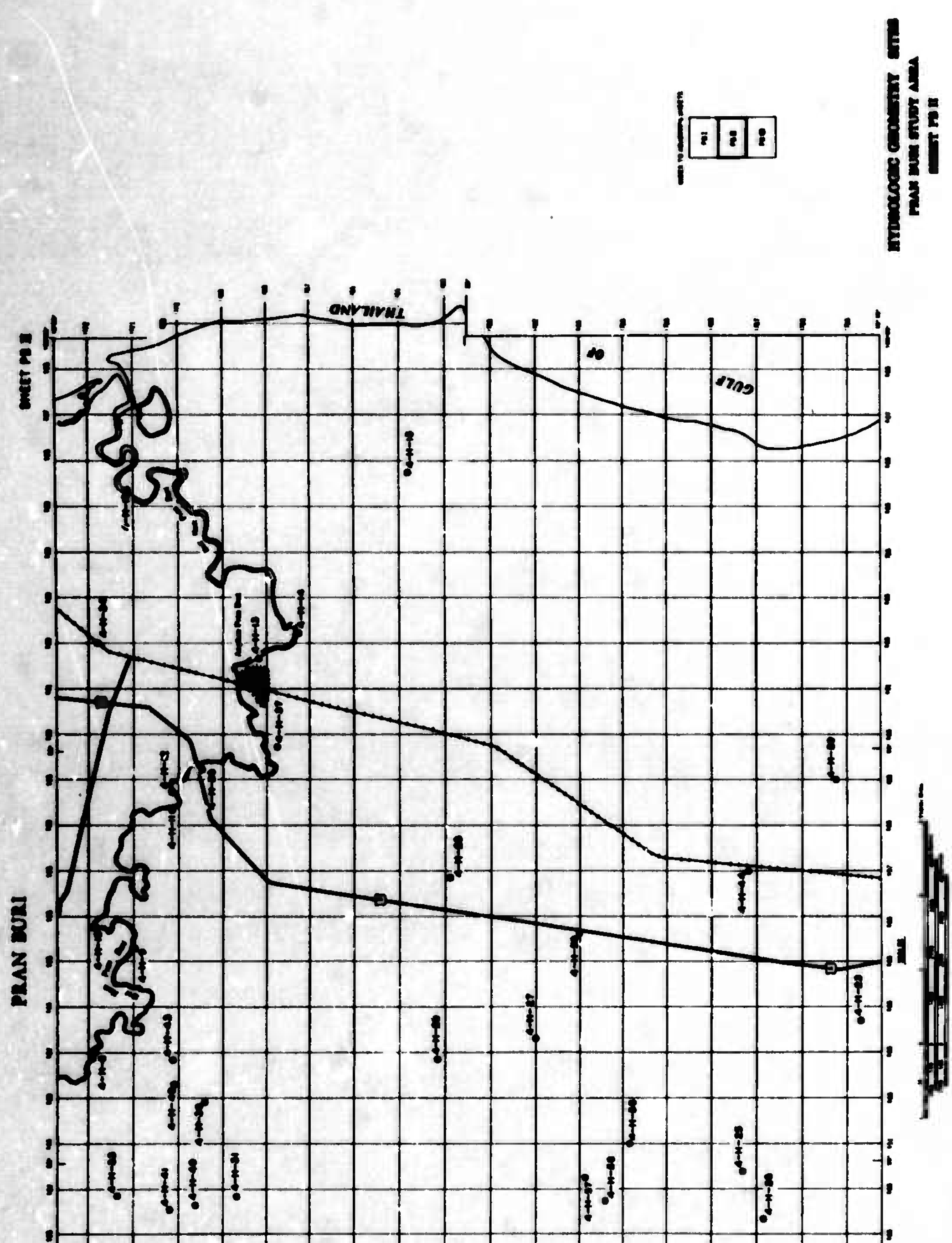

PRAN BURI
THAILAND
GULF
OF
HYDROLOGIC GEOMETRY SITES
PRAN BURI STUDY AREA
SHEET PB II

FIG. A17

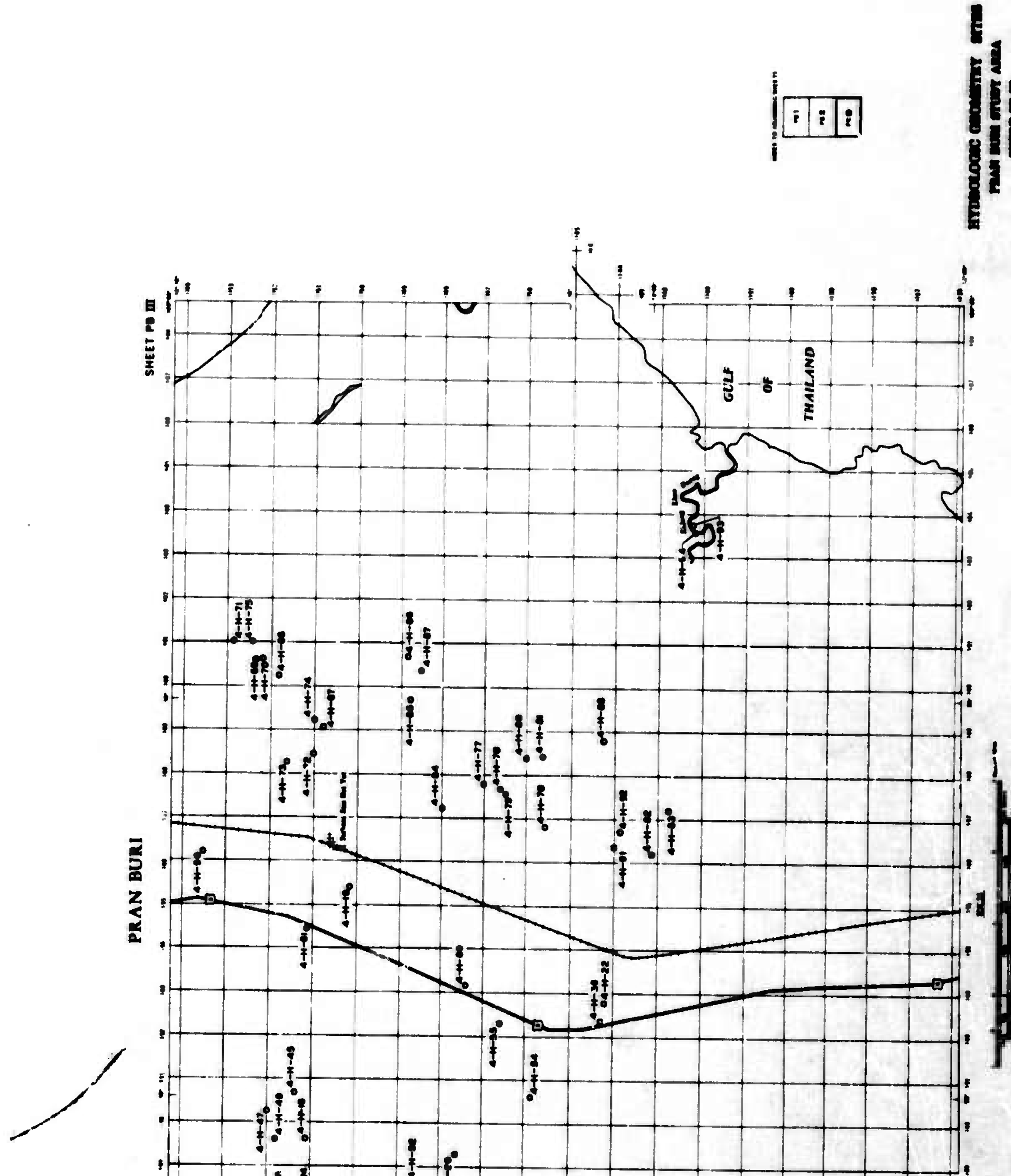


FIG. A18

KHON KAEN

Table A5

Summary of Hydrologic and Surface Geometry Field Data

Khon Kaen

				Hydrologic Geometry at East and West Banks														Water Depth ft		Surface Geometry												
				Contact Approach Angle, deg				Step** Height, in.				Position of Step Base,† in.								Critical Approach Angle, deg and Step Height, in.												
				Max Wtr		Min Wtr		Max Wtr		Min Wtr		Max Wtr		Min Wtr						1††		2		3	4	5	6	7		8		
Site No.	AMS Map Sheet	MSMS Quad No.	Military Grid Coordinates*	W	E	W	E	W	E	W	E	W	E	W	E	Max Wtr	Min Wtr	App Angle	Step Ht	App Angle	Step Ht	App Angle	App Angle	App Angle	App Angle	App Angle	Step Ht	App Angle	Step Ht	CD ft
5-M-1	5660III	KK III	909187													2	1					200	165	155	200					3
5-M-2A	5660III	KK III	936171													1.5	0					185	165	160	195	170	30			2
5-M-22	5660III	KK III	936171													2.5	0.5					200	160	155	195					3
5-M-3	5560I	‡	686296	110	175			72	30			-48	-36			5	2					240	110	100	210			155	18	6
5-M-4	5560I	‡	691298	150	130	150	130	34	20	34	20	-12	-54	+18	-18	5	3													
5-M-5	5560III	KK II	583200	165	167			36	66			0	-24			5	1	160	10	130	15	260	110	140	220					8
5-M-6	5560III	KK II	553200	160	155			18	30			-12	-12			4	2	125	16	140	28	200	150	90	270			130	14	5
5-M-7	5560III	KK II	550200	140	150				24				-24			5	1.5	130	12			250	130	140	210			160	24	5
5-M-8	5560III	KK I	342239													2	0.5	130	12			200	160	160	210			140	18	3
5-M-9	5560III	KK I	505195													2	1.0	150	16			210	150	170	190					2
5-M-10	5560III	KK I	471210	140	170											4	1.5					190	170	140	190					4
5-M-11	5560IV	‡	413261	160	155											8.5	2.0					210	145	140	195					12
5-M-12	5560III	KK I	369237	130	165			30	30			-24	-24			4	2	90	10			230	130	145	220					5
5-M-13	5460II	KK I	324240													2.5	1	140	20			220	150	120	250			145	14	3
5-M-14	5460II	‡	130254													2.5	0	130	06			260	100	160	200	170	12	155	8	3
5-M-15	5460I	‡	239323	150	165				36				-30			4	1.5	130	14			210	150	130	250					5
5-M-16	5460I	‡	240275	155	170			30				-18				3.5	1					220	145	170	190					5
5-M-17A	5460I	‡	239321	135	150	135	150	18	24	18	24	0	-36	+18	-24	4.5	3													
5-M-17B	5460I	‡	239321													1.5	0					220	130	120	230			140	14	3
5-M-17C	5460I	‡	239321													0		130	14			210	125	115	240			140	12	3
5-M-18	5460I	‡	240348	165	160											4	1.5					220	150	165	205					5
5-M-19	5560IV	‡	378272													1	0	160	6			220	150	125	230			115	12	2
5-M-20	5461II	‡	180458	130	150			72				-54				8	1.5					205	140	130	210					15
5-M-21	5461II	‡	121450	165	165			24	24			-6	0			4	1.5	130	12			210	160	105	270			115	16	6
5-M-22	5461II	‡	123449	155	150											3.5	1.5					215	150	155	215			120	[illegible]	[illegible]
5-M-23	5461II	‡	124445	175	165			48				-48				5	2	145	10			210	150	150	200					5
5-M-24	5560II	KK III	810184	150	145	160	166	36		48	30	-36		-48	-40	25	13													
5-M-25	5560II	KK II	654092	152	90	150	160	24		42		-24		0		41	30													
5-M-26	5560I	‡	643266													2.5	1					205	155	100	250					3
5-M-27	5560I	‡	636275													2	0.5					185	175	145	220			140	10	3
5-M-28	5560I	‡	626289	155	140											3	1	90	12			190	160	150	240					4
5-M-29	5560II	KK II	691247	155	170				16				-12			3.5	1					200	105	150	260					5
5-M-30	5560I	‡	687273	170	155			29				-27				4	.2	90	10			230	140	160	200					4
5-M-31	5460II	‡	170251													1.5	0	170	18	130	12	190	170	120	240			150	32	2
5-M-32	5461II	‡	185450	90	90											5	1					200	90	140	220			150	24	6
5-M-33	5460I	‡	239319													1	0	130	13			220	140	160	200			160	12	1
5-M-34	5560III	KK II	571188	150	140				78				0			5	1	155	60			235	140	160	230			140	40	7
5-M-35	5560III	KK II	572184	155	135			48				-36				4.5	1	150	12			190	170	120	220			150	12	6
5-M-36	5560III	KK II	573186	170	160											3	1	140	10			200	160	150	210			140	12	3
5-M-37	5560III	KK II	584226	155	165			12				+24				5.5	1.5	150	22	160	14	220	145	165	190					8

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.

** A step is a slope change that is >35 deg.

† Position of step base is referenced to water level.

†† For position of numerically designated approach angle and step height see fig. 6.

‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(1 of 3 sheets)

Table A5 (Continued)

Site No.	AMS Map Sheet	MRBS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg: Max Wtr W	Contact Approach Angle, deg: Max Wtr E	Contact Approach Angle, deg: Min Wtr W	Contact Approach Angle, deg: Min Wtr E	Step Height, in.: Max Wtr W	Step Height, in.: Max Wtr E	Step Height, in.: Min Wtr W	Step Height, in.: Min Wtr E	Position of Step Base, in.: Max Wtr W	Position of Step Base, in.: Max Wtr E	Position of Step Base, in.: Min Wtr W	Position of Step Base, in.: Min Wtr E	Water Depth ft: Max Wtr	Water Depth ft: Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
5-E-38	5560III	KK II	584228	165	90											5	1	130	14			270	90	160	220			130	36	7
5-E-39	5560II	KK II	705074													2.5	0	160	16			230	140	150	220					2
5-E-40	5560II	KK II	668117													2.5	1	135	12			200	165	120	230			150	12	2
5-E-41	5560II	KK II	739229	170	165	170	165									5	3													
5-E-42	5560II	KK II	738226	150	160	175	165	60	36	84	24	-14	+36	0	-24	18	8.5													
5-E-43	5560II	KK II	762160	155	172			36				-18				12	2					200	160	145	230					13
5-E-44	5560II	KK III	823185	105	160				48				-16			8	2	105	48			270	130	105	260	90	36			4
5-E-45	5560II	KK III	842166	160	170	165	170		36	18			+18	0		10	3													
5-E-46	5460II	KK I	249243	150	150	165	150		48	42			+54	-42		22	9													
5-E-47	5560II	KK II	775183	155	170	155	170	48	30	48	30	-22	-48	0	-18	5.5	3													
5-E-48A	5560II	KK II	680173	170	175											4.5	1.5	115	10	115	10	210	150	170	190	160	36			4
5-E-48B	5560II	KK II	680173	160	160	160	160									5	3													
5-E-49A	5560II	KK II	757178	175	170											5	2					200	160	165	200					4
5-E-49B	5560II	KK II	757178	160	155			40				-30				5.5						200	160	145	220					5
5-E-50	5560II	KK II	763182	153	105	165	165		48		48		-84		0	12	4.5													
5-E-51	5560II	KK III	844206	130	156			24								4	2					205	156	130	220					4
5-E-52	5560II	KK III	846206	115	130	155	160	18	46	18	46	-36	-54	+24	0	8.5	4													
5-E-53	5560I	*	716303	140	165	150	165	24	24	24	24	-22	-12	+24	+36	7.5	3.5													
5-E-54	5560I	*	715304	170	155			15	30			-6	-20			4	1.5					230	150	115	250			150	10	5
5-E-55	5560I	*	726286	170	170	170	170	[illegible]		38		-30		-18		4	3													
5-E-56A	5560I	*	722288													1.5	0					190	170	170	190					2
5-E-56B	5560I	*	722288	90	90			12	12			-30	-30			3	1.5	120	6			210	90	90	200					3
5-E-57	5560I	*	712335													2	0	150	24			220	160	165	210			155	[illegible]	3
5-E-58	5560I	*	725318	160	170	160	170	26	30	26	30	-26	-30	-8	-12	4.5	3													
5-E-59	5560I	*	725315	140	120			16				-12				3.5	1.5	150	10			220	150	145	220			120	6	3
5-E-60	5560II	KK II	647111	175	175			16	12			-16	-12			3.5	1.5					220	150	130	220					3
5-E-61	5560I	*	619293													2.5	0.5					240	130	170	190					3
5-E-62	5560I	*	607310													2.5	1	160	10			220	145	160	210			125	6	4
5-E-63	5560I	*	600321	150	125				42				-36			4	1.5					230	125	145	210					4
5-E-64	5560II	KK II	601167	172	155			48				-24				6	1					220	160	165	200					8
5-E-65	5560III	KK II	592155	165	150	165	150	30	24	30	24	-24	-24	0	0	5	3													
5-E-66	5560III	KK II	572142													2	0	140	18			210	150	90	230			120	12	3
5-E-67	5560III	KK II	556128	170	160				36				-24			3.5	0	160	24	150	12	230	130	155	200					4
5-E-68	5560II	KK II	689168	90	90											3.5	1.5					220	90	90	210					3
5-E-69	5560II	KK II	679174	165	90				36				-32			3	1.5	125	36			210	160	90	270			110	14	3
5-E-70	5560III	KK II	543116	155	150			12	24			-12	-18			6	1					220	150	155	210					7
5-E-71	5460II	*	260191	170	170			32	48			-22	-24			3.5	1.5					260	110	135	250			150	18	4
5-E-72	5460II	KK I	259193	175	165			36	20			-24	-20			3.5	1	120	12			260	115	110	260	155	10	100	20	4
5-E-73	5560III	KK I	361130													1.5	0	160	12			210	145	115	230					2
5-E-74	5560III	KK I	366128													2	0	130	32			230	155	145	220					3
5-E-75	5560III	KK II	587199	150	160	150	160	42	38	42	38	-42	-32	-12	+6	6	3													
5-E-76	5560III	KK II	535221	90	170			108	20			-102	-66			8.5	[illegible]	120	12			210	120	90	260	140	18	155	[illegible]	8.5
5-E-77	5460I	*	254328	170	170			12				0				3	1.5					200	160	160	240			150	14	4
5-E-78	5460I	*	317345	155	160	155	155									6	3.5													
5-E-79	5460I	*	246358	160	130			15	18			-10	-30			3.5	1					220	130	160	240			110	12	4
5-E-80	5560IV	*	361347	160	160											4.5	1					210	110	160	190	170	28	140	12	4
5-E-81	5460I	*	258311	175	175											3	1					190	175	150	210					3
5-E-82	5460I	*	196401	170	160			10	12			-36	-36			6	2	135	12	155	12	270	100	110	270					4
5-E-83	5460I	*	171373	140	150			22	24			-34	-12			3	1					210	145	140	220			140	10	4
5-E-84	5560III	KK I	437162	164	170	164	170	24		24		-16		+8		5	3													

(Continued)

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A5 (Concluded)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Contact Approach Angle, deg, Max Wtr, V	Contact Approach Angle, deg, Max Wtr, E	Contact Approach Angle, deg, Min Wtr, V	Contact Approach Angle, deg, Min Wtr, E	Stgr. Height, in., Max Wtr, V	Stgr. Height, in., Max Wtr, E	Stgr. Height, in., Min Wtr, V	Stgr. Height, in., Min Wtr, E	Position of Step Base, in., Max Wtr, V	Position of Step Base, in., Max Wtr, E	Position of Step Base, in., Min Wtr, V	Position of Step Base, in., Min Wtr, E	Water Depth ft, Max Wtr	Water Depth ft, Min Wtr	1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
5-H-85	5560III	NE I	484141	170	155	170	155	26	12	26	12	-44	-32	-18	-8	5.5	3.5													
5-H-86	5560III	NE I	485126	160	165				24				+4			5.5	2					200	140	110	220			150	16	6
5-H-87	5560III	NE I	489112	160	150	160	150	15	30	15	30	+10	-20	+46	+16	6	3													
5-H-88	5460II	NE I	244171	175	175			30	15			-20	-10			3	1.5					230	130	110	250			120	6	9
5-H-89	5460II	*	215160	160	160	160	160		12		12		-22		0	5	3													
5-H-90	5460II	*	213162	90	90	165	175			48	48			+6	+18	10	5													
5-H-91	5460II	*	210159	170	165			40	24			-28	-30			4.5	1.5					230	120	135	240			155	20	5.5
5-H-92	5460II	*	178162	165	170			24	24			-16	-4			3	0	160	6			230	120	120	250			130	12	3.5
5-H-93	5460II	*	174144	170	170			24	14			-6	-8			3.5	1.5	140	12			250	115	130	230			90	12	4
5-H-94	5560III	NE II	518248	150	170	145	165	24		24		-36		0		6	3													
5-H-95	5560IV	*	472290	130	130											4	1	160	10			230	130	130	240			140	24	4.5
5-H-96	5560IV	*	476293	145	160				48				+14			5	1	110	10	165	12	210	145	135	190					11
5-H-97	5560IV	*	473300	165	130	130	165		48		48		0		+72	9.5	3													
5-H-98	5560III	NE II	534215	160	150				14				0			4	1.5	120	18			200	150	160	185					4
5-H-99	5560III	NE II	529220													2.5	1					230	130	140	210	160	26	160	26	3
5-H-100	5560III	NE I	489224	150	130			20	16			0	-22			4.5	1.5	140	21			270	110	140	220			150	24	4.5
5-H-101	5560III	NE I	490209	160	160				36				-6			3.5	0	130	12			210	155	140	230			150	26	3.5
5-H-102	5560III	NE I	486195	160	160											3	0	160	24	160	24	210	160	175	185					4
5-H-103	5560IV	*	453341	125	140			60				0				6	1.5					265	110	140	185					6
5-H-104	5560IV	*	465335	145	175	150	140	28	18			-12	+24	+60	+96	9	3													
5-H-105	5560IV	*	469332	175	155			33	30			-6	-8			5	0					250	120	110	250					7
5-H-106	5560IV	*	478335													2.5	0.5	155	6			220	150	150	220			145	12	4
5-H-107	5560IV	*	487330	170	175											3.5	2	135	12			220	155	175	190					4
5-H-108	5560IV	*	546257	125	140	175	170	50	72	24	72	-50	-79	-8	-18	8	3													
5-H-109	5560IV	*	557265	90	170				20				-8			6	1	125	10			270	110	120	250					7
5-H-110	5560IV	*	569265	162	165			44	48			-36	-42			5	0			140	12	250	115	140	230					6
5-H-111	5560IV	*	546270	145	170			12	58			-44	-35			4.5	1					195	168	115	245					4.5
5-H-112	5560IV	*	537289	145	120			38	30			-36	-54			4.5	0.5	135	30	160	24	215	115	150	225			130	20	4
5-H-113	5560IV	*	538302	140	165				30				-18			5	0					220	140	140	200					5
5-H-114	5560IV	*	509313													2.5	0.5	130	30			200	155	130	225			160	10	2.5
5-H-115	5560IV	*	551337													2.5	0					210	150	90	270					6
5-H-116	5560I	*	626310	170	140			36	60			-32	-14			6.5	1.5					250	130	130	220			160	12	9.5
5-H-117	5560I	*	634310	155	120				10				-36			4	0	125	10			200	120	155	220			140	24	4.5
5-H-118	5560I	*	634307	115	145			24	48			-12	-48			5	0					220	145	115	230					6.5
5-H-119	5560I	*	637305	150	165			14				-14				4	1	140	10			200	160	145	220			145	6	4
5-H-120	5560IV	*	578322													2.5	1	160	14			210	120	155	205					4
5-H-121	5560IV	*	584343	130	110											4.5	1.5	135	84			260	115	125	235					5.5
5-H-122	5560IV	*	564345	150	130			30					0			3.5	0	130	30			250	130	150	230			150	24	4
5-H-123	5560IV	*	369272	170	115				12				-54			6	0.5					190	170	160	210					6.5
5-H-124	5560IV	*	365279													2	0	170	12			200	145	90	270			140	18	3.5
5-H-125	5560IV	*	361297													2.5	0.5					185	175	150	200					2.5
5-H-126	5560III	NE I	372193	150	165			18	14			-14	0			3.5	1	145	10	130	14	220	160	110	240					4
5-H-127	5560II	NE III	827221	160	160			10				-34				3.5	1.5					200	160	150	215					4.5
5-H-128	5560I	*	815295	165	170			18	20			-18	-18			3.5	1	110	18			230	130	100	270					4.5
5-H-129	5560I	*	817304	165	160			16	20			-12	-12			3	0	130	19			230	150	165	220					3
5-H-130	5560I	*	841261	170	170				40				-32			5.5	1.5					200	160	140	230					6
5-H-131	5560III	NE I	438123													2	0					260	100	110	230					2.5
5-H-132	5560I	NE I	442119	170	150			32				-24				4	1.5	140	24			230	140	150	230			145	22	4.5
5-H-133	5560III	NE I	430152													2.5	1	130	18			210	160	155	190					3

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

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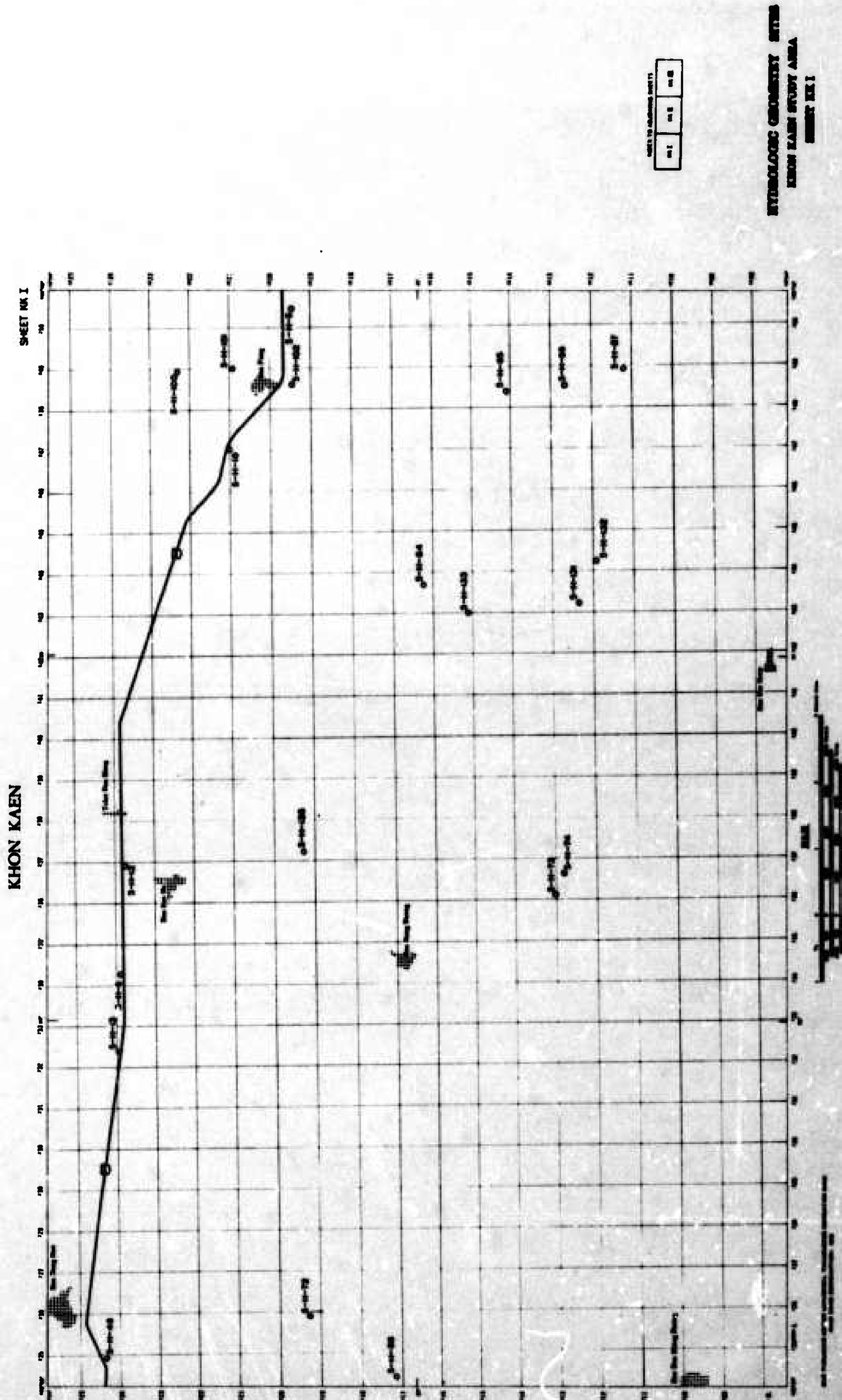
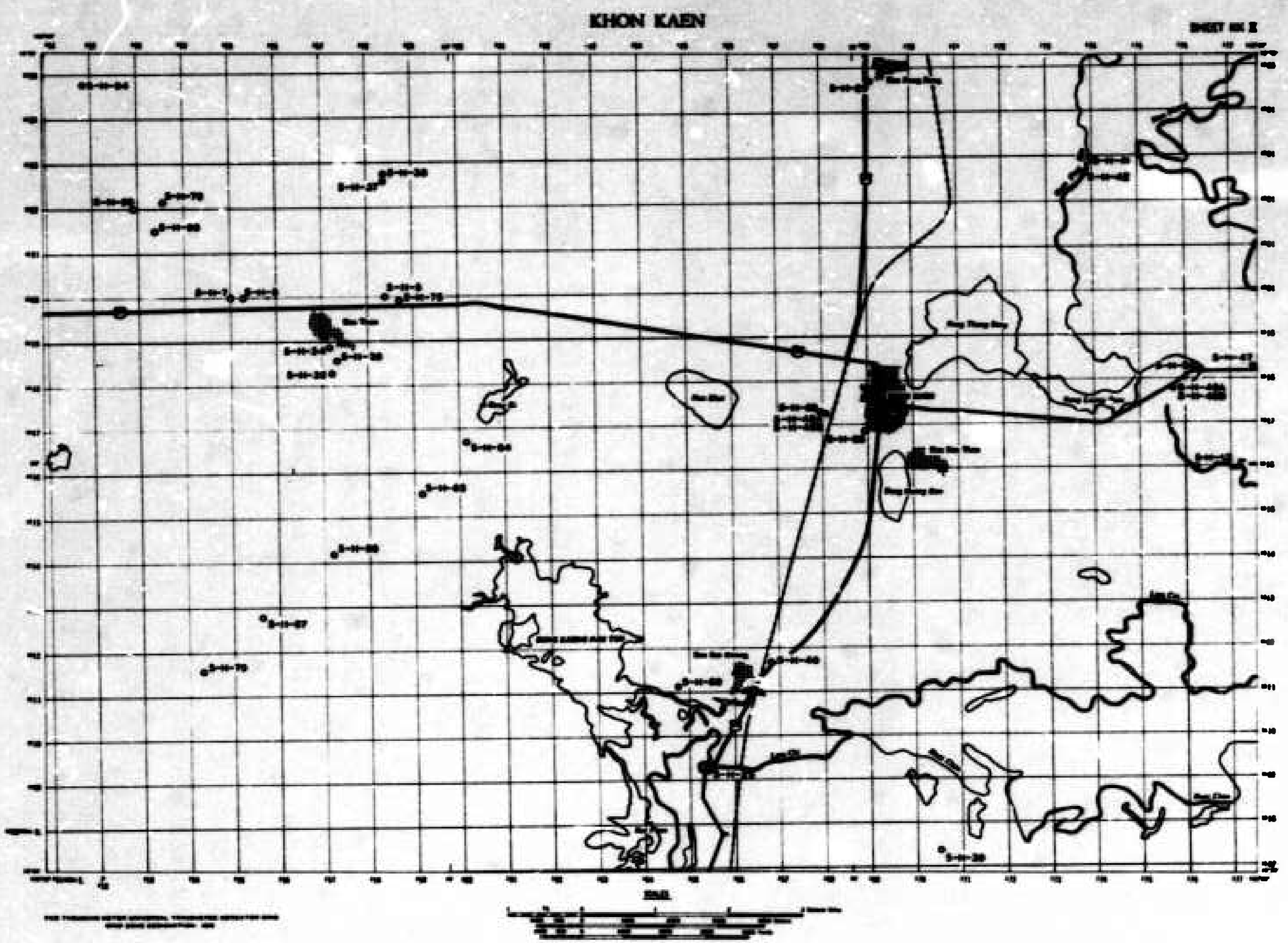


FIG. A19



HYDROLOGIC GEOMETRY SITES
KHON KAEN STUDY AREA
SHEET KK II

FIG. A20

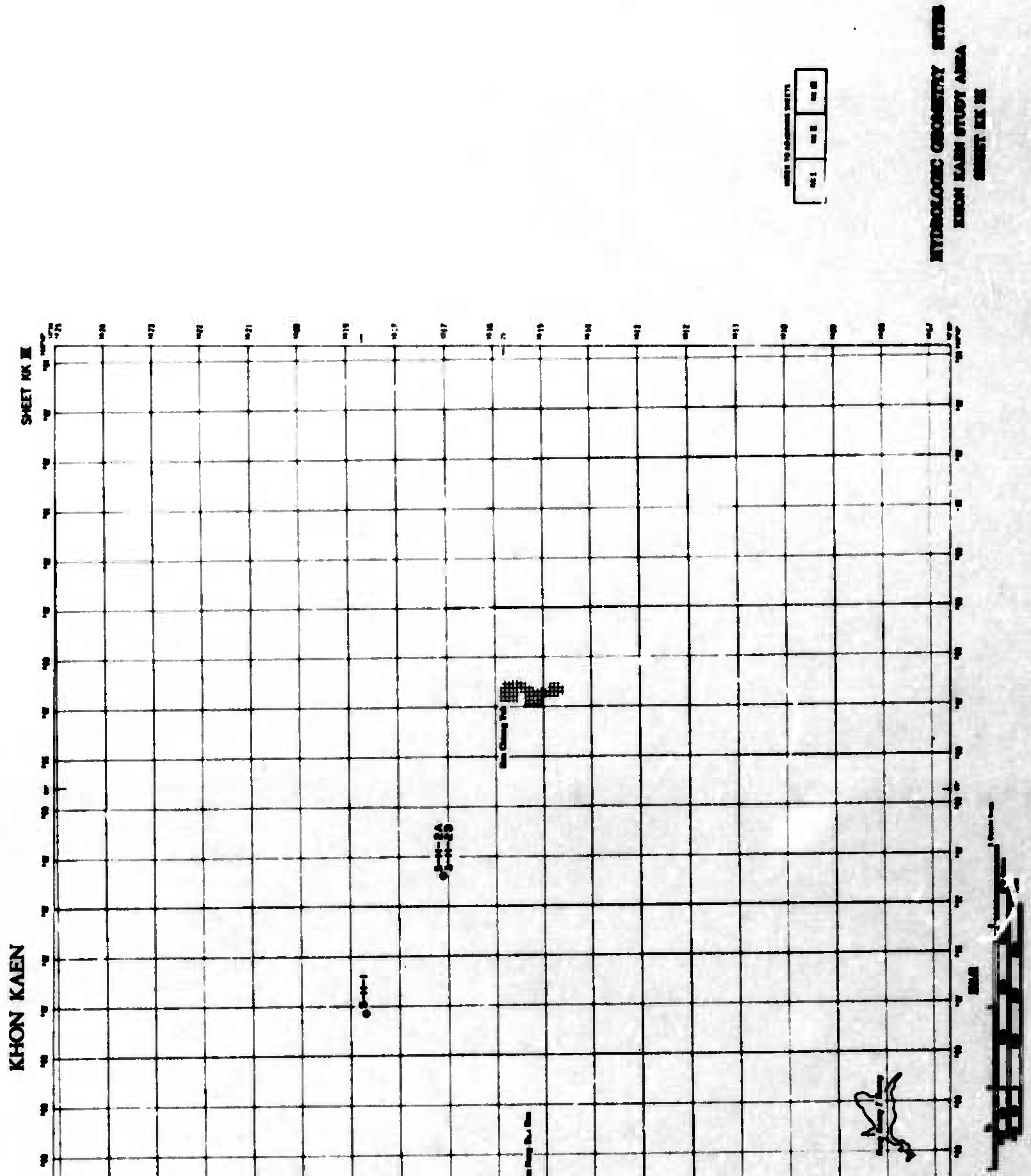


FIG. A21

CHANTHABURI

Table A6

Summary of Hydrologic and Surface Geometry Field Data

Chanthaburi

				Hydrologic Geometry at East and West Banks												Water Depth ft		Surface Geometry														
				Contact Approach Angle, deg				Step** Height, in.				Position of Step Base,† in.						Critical Approach Angle, deg and Step Height, in.														
				Max Wtr		Min Wtr		Max Wtr		Min Wtr		Max Wtr		Min Wtr				1††		2		3	4	5	6	7		8		
Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates*	W	E	W	E	W	E	W	E	W	E	W	E	Max Wtr	Min Wtr	App Angle	Step Ht	App Angle	Step Ht	App Angle	App Angle	App Angle	App Angle	App Angle	Step Ht	App Angle	Step Ht	CD ft
6-H-1	5349II	C I	168092	130	95											5	1					230	125	95	265					5
6-H-2A	5349II	C I	158090	140	170											3	0					220	140	170	190					3
6-H-2B	5349II	C I	158090													1	0					190	170	175	190					1
6-H-3	5349II	C I	218085	155	115											11	2					240	155	120	210					11
6-H-4	5349II	C I	217086	90	130											10	2					195	125	120	190					10
6-H-5	5349II	C I	151068	172	170			48				-36				5	1	175	12			240	170	175	185					5
6-H-6	5349II	C I	153079	175	175											7	1					195	165	160	185					7
6-H-7	5349II	C I	166088	155	160				40				-40			6	2					190	170	150	195					8
6-H-8	5448IV	C III	805955													1	0					270	90	165	185					1
6-H-9	5348I	C II	130998	125	125											4	1					230	145	125	195			140		
6-H-10	5349II	C I	202096	145	165	135	170			36				0	-36	20	9													
6-H-11	5448IV	C III	881961	175	170			36	28			-20	-28			5	2					215	165	165	230					5
6-H-12	5448IV	C III	888990	175	170	175	170	12	42	12	42	-12	-24	+20	+8	6	3													
6-H-13	5448IV	C III	917923	130	150				28				-45			6	1					190	130	130	185					9
6-H-14	5448IV	C III	918913	90	155											8	1					270	160	155	190					10
6-H-15	5448IV	C III	917864	160	155											13	1					210	155	160	200					16
6-H-16	5448IV	C III	893841	100	110											5	1					190	110	100	230					5
6-H-17	5448IV	C III	893837	160	150	140	145		18		18		0	+54		9	4													
6-H-18A	5448IV	C III	850942	160	130											3	0					195	130	155	195					3
6-H-18B	5448IV	C III	850942													2	0					185	160	160	185					2
6-H-19	5448IV	C III	871930													2	0					200	160	90	260					2
6-H-20	5448IV	C III	924983	160	160			24				0				3	0					195	170	160	250					3
6-H-21	5448IV	C III	759003	170	155			42	42			-48	-30			11	2					250	100	165	220					12
6-H-22	5448IV	C III	795003	140	140											15	1					215	120	160	215					20
6-H-23	5448IV	C III	819012	140	130				42			-42				5	1					195	150	120	230					5
6-H-24	5448IV	O III	994017	125	150				16				-6			5	1					200	155	120	190					7
6-H-25A	5448IV	C III	889989	170	160											3	1					210	170	160	200					4
6-H-25B	5448IV	C III	889989	110	145											4	1					260	110	145	210					4
6-H-26	5448IV	C III	896986	170	150	160	165	102		102		-48		+24		10	3													
6-H-27	5448III	C IV	893813	160	170	170	165	48		48		0		+84		11	4													
6-H-28	5349II	C I	219101	120	120											8	1					200	165	170	200					11
6-H-29	5349II	O I	234078	170	130			65				-42				8	1					230	135	120	215					10
6-H-30A	5349II	C I	247056													1	0					200	155	150	190					1
6-H-30B	5349II	O I	247056	130	105											5	0					210	160	100	260					5
6-H-31	5449III	♦	749039													2	0					200	170	130	240					2
6-H-32	5448IV	C III	753016	120	145	90	115									7	3													
6-H-33	5448III	O IV	869794													2	0					185	175	145	220			150	24	2
6-H-34	5448IV	C III	918903	125	115				96				-48			7	2					210	90	90	220					7.5
6-H-35	5448IV	C III	914886	155	125	120	110	42				-42				9	3													
6-H-36	5448IV	C III	913888	90	135				42				+30			5	1					250	135	90	270					5

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
** A step is a slope change that is >35 deg.
† Position of step base is referenced to water level.
†† For position of numerically designated approach angle and step height see fig. 6.
♦ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(1 of 3 sheets)

Table A6 (Continued)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry, at East and West Bank: Contact Approach Angle, deg, Max Wtr V	Contact Approach Angle, Max Wtr X	Contact Approach Angle, Min Wtr V	Contact Approach Angle, Min Wtr X	Step Height, in., Max Wtr V	Step Height, Max Wtr X	Step Height, Min Wtr V	Step Height, Min Wtr X	Position of Step Base, in., Max Wtr V	Position of Step Base, Max Wtr X	Position of Step Base, Min Wtr V	Position of Step Base, Min Wtr X	Water Depth ft, Max Wtr	Water Depth ft, Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
6-H-37	5448III	C IV	935822	90	90											5.5	0.5					250	110	90	270					5
6-H-38	5448III	C IV	939815	140	90											4	0					260	100	140	190					4
6-H-39	5448IV	C III	830929	175	175											4	1.5					210	155	175	185					2.5
6-H-40	5449III	*	801112	155	130											6.5	1.5					200	150	120	280					7
6-H-41	5449III	*	805090	130	135	160	160			30	24			-14	-18	6.5	3.5													
6-H-42	5449III	*	801084													1.5	0.5					190	160	125	190					3
6-H-43	5449III	*	805074													2.5	0.5					250	105	165	195					3
6-H-44	5449III	*	805055													2.5	0.5					240	150	90	270					3.5
6-H-45	5448IV	C III	803016	145	150											9.5	0					200	120	135	200					12
6-H-46	5448IV	C III	800924													2.5	0.5					185	170	170	190					2.5
6-H-47	5448IV	C III	814918	140	170	140	170									5	3													
6-H-48	5448IV	C III	813904	160	140	125	140	12		30		-12		-78		8.5	7.5													
6-H-49	5448IV	C III	760963													2	0.2					225	135	130	250			110	30	3
6-H-50	5349II	C I	099113													1.5	0	130	10			250	110	146	215					2
6-H-51	5349II	C I	095107	150	130											7	1					200	140	135	220					7
6-H-52	5348I	C II	132950													2	0	140	12			220	150	155	195					2
6-H-53	5348I	C II	149970	120	90											6.5	0					270	90	90	270			150	25	7.5
6-H-54	5349II	C I	015110													2.5	1.5	150	10			230	130	90	270					3
6-H-55	5349II	C I	030050	175	175											3.5	1.5					185	175	175	185					4.5
6-H-56	5349II	C I	011068													2.5	1	125	18			250	120	160	190			170	24	4.5
6-H-57	5349II	C I	070087	160	155											3.5	1.5					210	155	160	200					4
6-H-58	5449III	*	849020	165	147	120	160			12	34			-36	-24	9	3					250	110	120	240					5.5
6-H-59	5449III	*	849030	110	160			48	20			-54	-12			4.5	0					210	145	155	200					4.4
6-H-60	5449III	*	849038	145	155											5	0					185	160	165	190					3.5
6-H-61	5449III	*	855066													2.5	0													
6-H-62	5449III	*	835091	160	165			30	90			-20	-48			7.5	2					270	90	135	220					13
6-H-63	5449III	*	837092	155	140			79	36			-54	-54			6.5	1.5					220	145	160	200					6.5
6-H-64	5448IV	C III	926841	136	150				60				+60			9	0					220	130	110	240					12
6-H-65	5448III	C IV	955799	135	125				48				-48			8	0			150	48	230	135	125	230	145	24			14
6-H-66	5448III	C IV	965795	165	170			60	24			-36	-24			4	1					195	145	130	230	116	60			12
6-H-67	5448III	O IV	973794	115	131			54	54							9	1					210	130	115	210					9.5
6-H-68	5448IV	C III	932857	165	160			24	24			0	-24			3	0.5					220	140	125	225					4
6-H-69	5448IV	C III	745964	170	165			30	42			-30	-30			6	2					260	160	150	250			175	18	6
6-H-70	5449III	*	957021	90	165				20				-20			5	1					270	165	90	270					5
6-H-71	5448IV	*	913974	170	170			26				-26				3	1					220	165	170	190					3
6-H-72	5448IV	C III	925985	175	160				30				-46			6	1					200	170	160	235					6
6-H-73	5448IV	C III	930987													2	0					195	165	170	185					2
6-H-74	5448IV	C III	938993	130	140											7	2					195	115	120	185					7
6-H-75	5448IV	C III	944005	130	130				24				-24			4	1					190	130	140	250					4
6-H-76	5448IV	C III	949018	150	90			42				-42				5	1					250	150	90	250					5
6-H-77	5449III	*	977057	165	160			34	48			-34	-36			4	1					240	160	150	220					4
6-H-78	5448IV	C III	969017	160	140			60				-48				8	1					250	110	145	190					8
6-H-79	5449III	*	955021	90	100				24				-24			5	1					260	110	105	270					5
6-H-80	5448IV	C III	976009	160	110			48				-48				7	1					240	160	110	250					7
6-H-81	5448IV	C III	980999	100	100											6	1	170	8			230	120	100	210					6
6-H-82	5448IV	C III	986989	160	170				12				-12			3	0					185	160	140	210			140	12	3
6-H-83	5449III	*	829079	160	160											7	1					205	150	140	200					7
6-H-84	5448IV	C III	862948													2	0					190	165	165	185					2
6-H-85	5448IV	C III	845965	170	100											3	0					270	100	170	190					3
6-H-86	5448IV	C III	812968	140	130											7	2					190	150	100	210					7

(Continued)

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A6 (Concluded)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks: Contact Approach Angle, deg, Max Wtr W	Contact Approach Angle, Max Wtr E	Contact Approach Angle, Min Wtr W	Contact Approach Angle, Min Wtr E	Step Height, in., Max Wtr W	Step Height, Max Wtr E	Step Height, Min Wtr W	Step Height, Min Wtr E	Position of Step Base, in., Max Wtr W	Position of Step Base, Max Wtr E	Position of Step Base, Min Wtr W	Position of Step Base, Min Wtr E	Water Depth ft, Max Wtr	Water Depth ft, Min Wtr	Surface Geometry: Critical Approach Angle, deg and Step Height, in.: 1 App Angle	1 Step Ht	2 App Angle	2 Step Ht	3 App Angle	4 App Angle	5 App Angle	6 App Angle	7 App Angle	7 Step Ht	8 App Angle	8 Step Ht	CD ft
CRREL Sites**																														
6-E-8-3	5449III	*	978058	145	150			24	48			-30	-3[illegible]			7.5	1.5					270	120	110	260					8
6-E-9-1	5349II	*	158090	135	145											9	1.5					190	140	135	200					10
6-E-9-3	5349II	*	200079													2.5	0					190	160	130	250					3
6-E-9-5	5349II	*	232077	130	140											7	0					190	130	140	200					7
6-E-9-6	5349II	*	252052	115	125			36	36			-54	-42			5	0					230	125	115	[illegible]					5.5
6-E-9-7	5449III	*	750038													2.5	0					210	145	110	250					3
6-E-9-8	5449III	*	752027													2.5	0					250	[illegible]	110	250					3.5
6-E-11-5	5448IV	CM III	936863	165	135			36	42			-56	-36			5	1					260	120	90	270					5.5
6-E-13-1	5448IV	*	754020	90	90											5	1					210	110	90	240					5.5
6-E-13-4	5448IV	C III	819012	90	90											5	0					200	90	90	210					7
6-E-13-6	5448IV	C III	868014													2	0					200	160	90	220					2.5
6-E-15-8	5448IV	C III	929842	90	90											4.5	1					240	90	90	240					5
6-E-17-4	5448III	C IV	933823	90	90											4	1					250	110	90	230					5
6-E-17-5	5448III	C IV	936817	140	130			48				-48				5.5	0					200	130	120	240					6
6-E-17-6	5448III	C IV	995787	90	165	90	90			108	48			-24	0	9	3													
6-E-17-7	5448III	C IV	982799	125	160				42				-36			7	0.5					225	90	90	215					7.5
6-E-17-8	5448III	C IV	966796													2.0	0					270	90	90	250					2.5
6-E-17-9	5448III	C IV	956799	140	140			48	36			-24	-66			6.5	0					210	90	90	220					7
6-E-19-2	5448III	C IV	383740	110	90											5	2					230	100	90	240					5.5

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.
** Not recorded on maps.

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HYDROLOGIC GEOMETRY SITES
CHANTHABURI STUDY AREA
SHEET C I

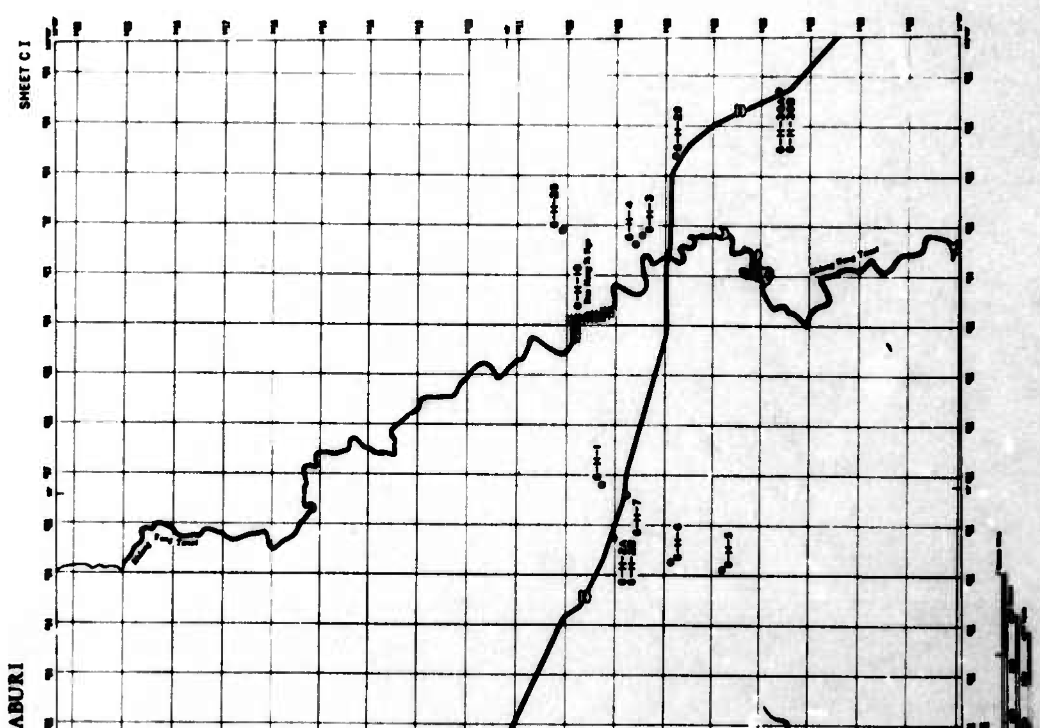

FIG. A22

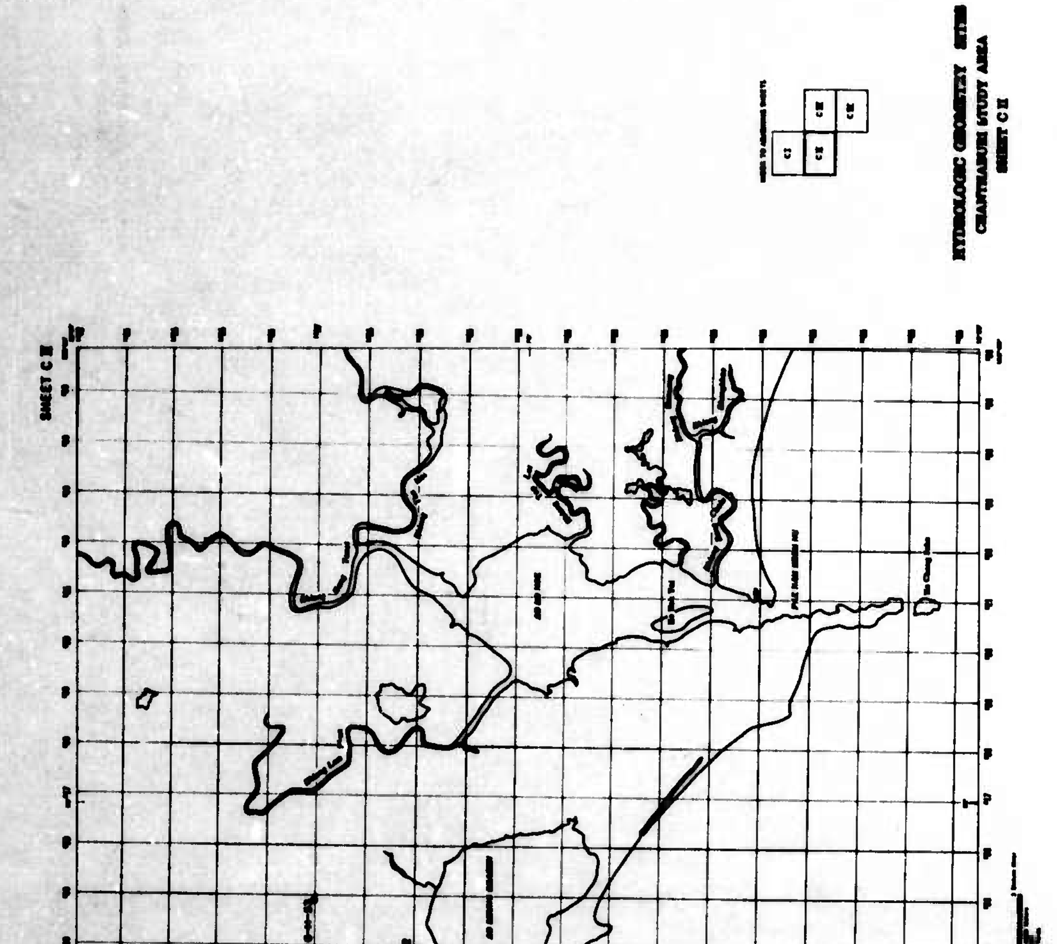

FIG. A23

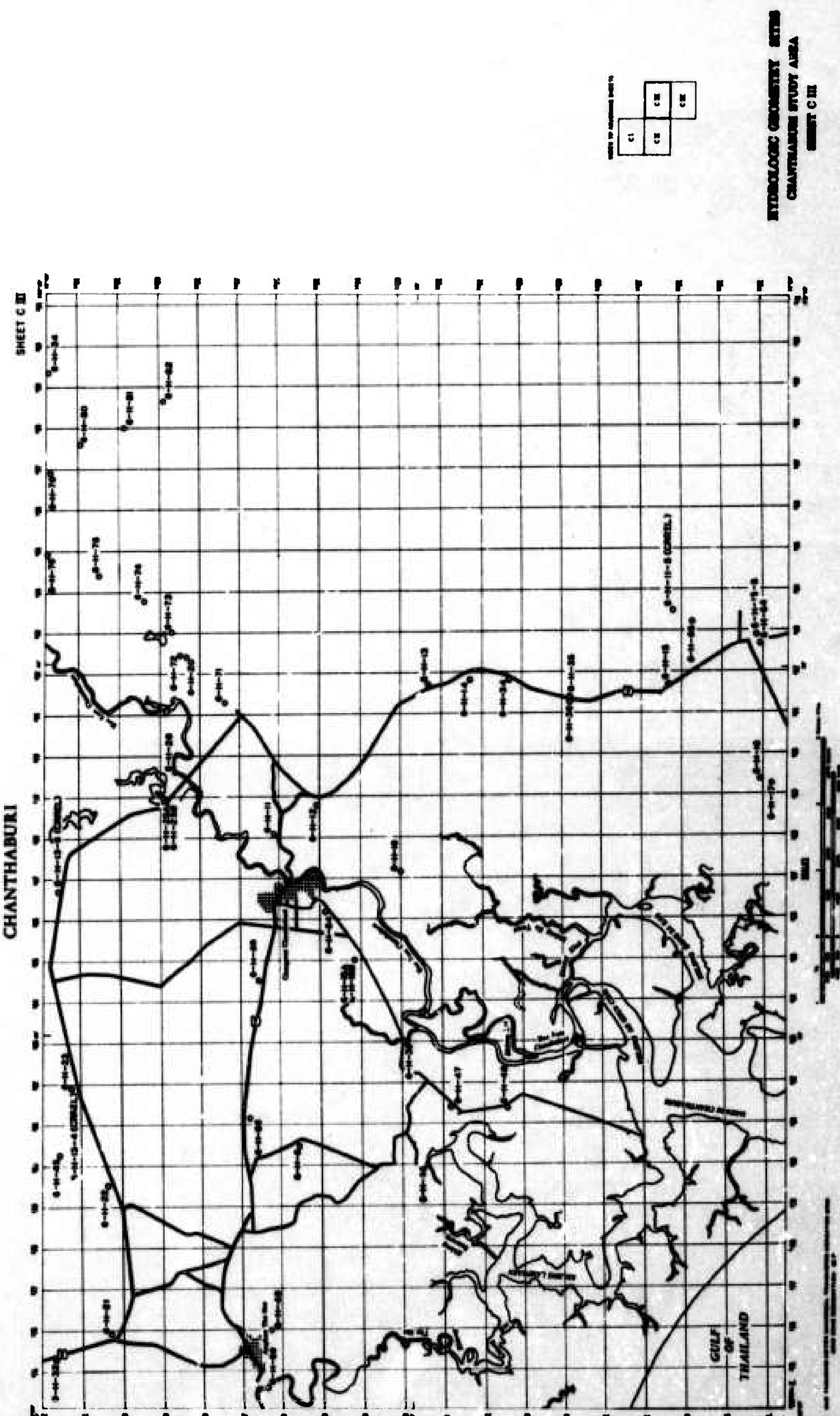
CHANTHABURI
SHEET C III
GULF OF THAILAND
HYDROLOGIC GEOMETRY SITES
CHANTHABURI STUDY AREA
SHEET C III

FIG. A24

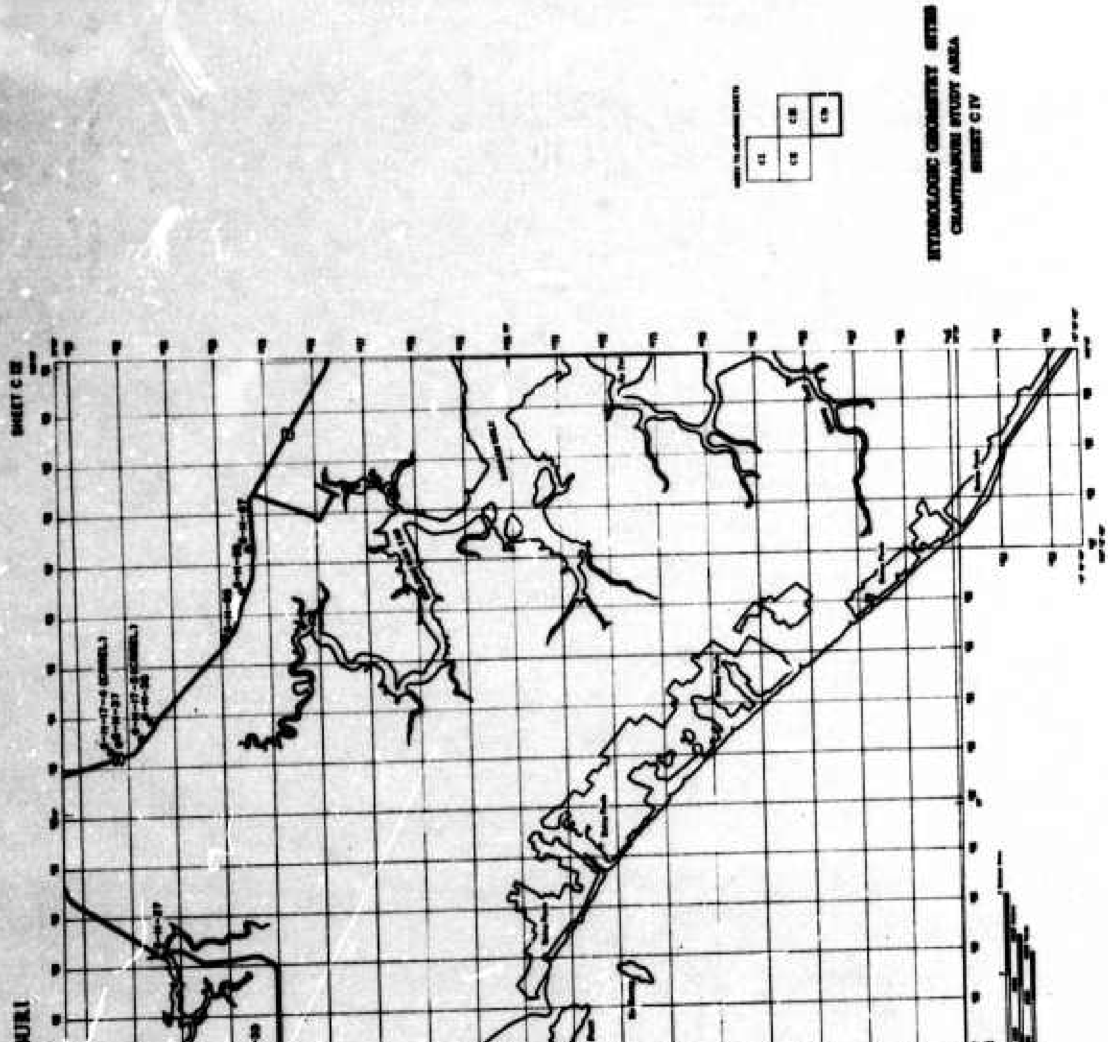
CHANTHABURI
GULF OF THAILAND
HYDROLOGIC CHEMISTRY SITES
CHANTHABURI STUDY AREA
SHEET C IV

FIG. A25

Unclassified

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13. ABSTRACT

This volume presents the methods used in collecting hydrologic geometry data in selected areas in Thailand. The selection, analysis, and classification of parameters significant to vehicle mobility are discussed. The photo-interpretation methods used in identifying hydrologic geometry features from aerial photographs (air photos) and the extrapolation of these identifications to areas not investigated on the ground are presented. The rationale for cartographic portrayal of these parameters is explained. Utilizing the collected field data, available air photos, and the Army Map Service series of topographic maps, hydrologic geometry factor maps were prepared covering the six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Chanthaburi, Pran Buri, and Khon Kaen). The maps are presented in Volume VIII of this series. It proved only partially possible to determine the existence and value of the chosen parameters from air photos since some of the individual factors are wholly or partially below the water surface. Nevertheless, photo interpretation plus extrapolation from measured sites made it possible to map the parametric values by class range with reasonable validity. Recommendations are made involving improvement in data-collection techniques.

Unclassified

Security Classification

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Environmental studies						
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Thailand						

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